OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL COVER SHEET
Complete Only Applicable Items

1. QA: QA

2. ☒ Analysis	Check all that apply	3. ☐ Model	Check all that apply
Type of Analysis	☒ Engineering ☐ Performance Assessment ☐ Scientific	Type of Model	☐ Conceptual Model ☐ Abstraction Model ☐ Mathematical Model ☐ System Model ☐ Process Model
Intended Use of Analysis	☐ Input to Calculation ☐ Input to another Analysis or Model ☒ Input to Technical Document ☒ Input to other Technical Products	Intended Use of Model	☐ Input to Calculation ☐ Input to another Model or Analysis ☐ Input to Technical Document ☐ Input to other Technical Products
Describe use:	Provide input to SR Consideration Report. Provide input to drawings for the drip shield and emplacement pallets.	Describe use:	

4. Title:

Design Analysis for the Ex-Container Components

5. Document Identifier (including Rev. No. and Change No., if applicable):

ANL-XCS-ME-000001 REV 00

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7. Attachment Numbers - No. of Pages in Each:

I - 3, II - 3, III - 2

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00	Initial Issue

CONTENTS

Page

FIGURES

Page

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TABLES

Page

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ACRONYMS

AMR	Analysis/Model Report
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BWR	boiling water reactor
CPA	Controlled Project Assumption
CRWMS	Civilian Radioactive Waste Management System
DHLW	defense high-level waste
DOE	U.S. Department of Energy
ICD	Interface Control Document
LA	License Application
MGR	Monitored Geologic Repository
MT	metric tons
M&O	Management and Operating Contractor
PDD	Project Description Document
PTn	Paintbrush tuff nonwelded
PWR	pressurized water reactor
QA	quality assurance
QAP	Quality Administrative Procedure
SCC	stress corrosion cracking
SDD	System Description Document
SNF	spent nuclear fuel
SR	Site Recommendation
SS	stainless steel
SSCs	structures, systems, and components
TBD	to be determined
TBV	to be verified
TDMS	Technical Data Management System
TSPA	Total System Performance Assessment
TSw1	Topopah Spring welded unit 1-lithophysal rich
UNS	Unified Numbering System
WP	waste package

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1. PURPOSE

The purpose of this analysis is to describe the designs for the drip shield and emplacement pallet. In this analysis, the results of design calculations are summarized and used to show that the designs are in compliance with the applicable criteria in the *Emplacement Drift System Description Document* (SDD, CRWMS M&O 2000k). The depth of this analysis is such that it illustrates the application of the design methodology, as documented in the *Waste Package Design Methodology Report* (CRWMS M&O 2000a). The scope of this analysis is limited to reporting the results of the design calculations performed for Site Recommendation (SR) for the drip shield and emplacement pallet. The calculations required for SR are identified in the *Waste Package Design Sensitivity Report* (CRWMS M&O 2000b). This analysis was prepared following the technical product development plan *Design Analysis for the Ex-Container Components* (CRWMS M&O 2000i). The objective of this analysis is to draw conclusions from calculations performed to justify dimensions in the designs. The intended use of this analysis is to provide input to design drawings for the drip shield and emplacement pallets. This is an appropriate use of this analysis since it documents compliance of the drip shield and emplacement pallet concepts with the criteria given in the SDD (CRWMS M&O 2000k).

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2. QUALITY ASSURANCE

The Quality Assurance (QA) program applies to this analysis. The drip shields and support hardware (emplacement pallets) were classified (per QAP-2-3, *Classification of Permanent Items*) as Quality Level-1 in *Classification of the MGR Ex-Container System* (CRWMS M&O 1999c, p. 8). The development of this analysis is conducted under activity evaluation *Waste Package Design Methodology and AMRs – 1101 2125 M1* (CRWMS M&O 1999d), which was prepared per QAP-2-0, *Conduct of Activities*. Note that QAP-2-0, *Conduct of Activities*, has been superseded by AP-2.16Q, *Activity Evaluation*; however, CRWMS M&O 1999d was written prior to the effective date of the new procedure. The results of that evaluation were that the activity is subject to the *Quality Assurance Requirements and Description* (DOE 2000) requirements. The methods used to control the electronic management of data as required by AP-SV.1Q, *Control of the Electronic Management of Data*, have been accomplished in accordance with the controls specified in the technical product development plan *Design Analysis for the Ex-Container Components* (CRWMS M&O 2000i).

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3. COMPUTER SOFTWARE AND MODEL USAGE

No computer software or models were used in the generation of this analysis.

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4. INPUTS

4.1 DATA AND PARAMETERS

All data and parameters used as inputs are referenced from codes and standards and are accepted data – fact. Therefore, they are appropriate for their intended purpose in this analysis.

4.1.1 Material Properties for 316L Stainless Steel

316L Stainless Steel (identified as SA-240 S31603 in Attachment III) is the material selected for the emplacement pallet tubes. The following material properties are used in this analysis.

- Sy (yield strength) = 172 MPa (25 ksi, ASME 1995, Table Y-1, pp. 512-515, line 20)
- Su (ultimate tensile strength) = 483 MPa (70 ksi, ASME 1995, Table U, pp. 436-437, line 6)

4.1.2 Material Properties for Titanium Grade 7

Titanium Grade 7 (identified as SB-265 R52400 in Attachment II) is the material selected for the drip shield plates. The Unified Numbering System (UNS) number for titanium Grade 7, R52400, is taken from *Metals & Alloys in the Unified Numbering System* (SAE 1993, p. 242). The following material property is used in this analysis.

- Sy = 275 MPa (40 ksi) (ASTM B 265-99, *Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate*, Table 1, p. 2)

4.1.3 Material Properties for Titanium Grade 24

Titanium Grade 24 (identified as SB-265 R56405 in Attachment II) is the material selected for the drip shield structural members. The UNS number for titanium Grade 24, R56405, is taken from *Metals & Alloys in the Unified Numbering System* (SAE 1993, p. 243). Note that prior to finding the UNS number for titanium Grade 24, the UNS number listed in some of the referenced calculations is R56400, which is for titanium Grade 5 (SAE 1993, p. 243), of which Grade 24 is a derivative. The following material property is used in this analysis.

- Sy = 828 MPa (120 ksi) (ASTM B 265-99, Table 1, p. 2)

4.1.4 Material Properties for Alloy 22

Alloy 22 (identified as SB-575 N06022 in Attachments I and II) is the material selected for the waste package outer barrier and the emplacement pallet plates. The following material properties are used in this analysis.

- Sy = 310 MPa (45 ksi) (ASTM B 575-99a, *Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-*

Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip, Table 4, p. 3)

- Su = 690 MPa (100 ksi) (ASTM B 575-99a, Table 4, p. 3)

4.2 CRITERIA

The emplacement drift system has a number of functions, which are listed in Table 1.

Table 1. Functions of the Emplacement Drift System

SDD Section	Function
1.1.1	The system contributes to the isolation of high-level waste from the Natural Barrier.
1.1.2	The system limits the likelihood of a self-sustainable fission reaction (external criticality) in both the near field and the far field.
1.1.3	The system limits the effect of rockfall on the waste package (WP).
1.1.4	The system provides a physical WP support for WPs within emplacement drifts.
1.1.5	The system influences the environment within emplacement drifts to protect WPs and the Natural Barrier.
1.1.6	The system limits the movement of radionuclides to the Natural Barrier upon WP breach.
1.1.7	The system limits microbial activity.
1.1.8	The system allows periodic inspection, testing, and maintenance of structures, systems, and components (SSCs) prior to permanent closure.

Source: CRWMS M&O 2000k

4.2.1 Emplacement Drift System Description Document

The Emplacement Drift SDD (CRWMS M&O 2000k) provides a list of performance criteria for the drip shield and emplacement pallet that is consistent with upper tier requirements documents and will result in the drip shield and emplacement pallet meeting those requirements. These criteria are divided into the following six broad classes:

1. System Performance Criteria
2. Safety Criteria
3. System Environment Criteria
4. System Interfacing Criteria
5. Operational Criteria
6. Codes and Standards Criteria.

This section of the analysis will re-iterate those criteria. Certain other criteria are not presently addressed in this analysis. They are enumerated in Table 2.

Table 2. Omitted Criteria and Basis for Omission

SDD Section	Summary	Basis for Omission
1.2.1.1	The system shall be designed such that when collectively assessed with the waste packages (WPs) and the natural barrier the expected annual dose to the average member of the critical group shall not exceed 0.25 mSv (25 mrem) total effective dose equivalent at	Total System Performance Assessment (TSPA) to show compliance. Outside of the scope of this analysis.

	any time during the first 10,000 years after permanent closure, as a result of radioactive materials released from the geologic repository.	
1.2.1.2	Capacity of Repository	Independent of drip shield and emplacement pallet design.
1.2.1.4	Limit Pillar Temperature for Repository Closed Between 50 and 125 Years After Initial WP Emplacement.	Independent of drip shield and emplacement pallet design.
1.2.1.7	Fault Standoff	Independent of drip shield and emplacement pallet design.
1.2.1.8	Water Drainage Via Emplacement Drift Floor	Independent of drip shield and emplacement pallet design.
1.2.1.9	Invert Composed of Carbon Steel	Independent of drip shield and emplacement pallet design.
1.2.1.10	Ballast Maintain pH of Water	Independent of drip shield and emplacement pallet design.
1.2.1.11	Granular Ballast Material	Independent of drip shield and emplacement pallet design.
1.2.1.12	The drip shield shall have an operating life of 10,000 years.	TSPA to show compliance. Outside of the scope of this analysis.
1.2.1.19	Backfill Maintain pH of Water	Independent of drip shield and emplacement pallet design.
1.2.2.1.1	System Permit Operations with WP Lift Height Limited to 2.4 m Above Invert	Independent of drip shield and emplacement pallet design.
1.2.2.2.1	Consideration of Safety Hazards of Ballast and Backfill Materials	Independent of drip shield and emplacement pallet design.
1.2.3.2	Limit Temperature of Zeolite Layers	Independent of drip shield and emplacement pallet design.
1.2.3.3	Limit Temperature Change 45 cm Below Soil Surface	Independent of drip shield and emplacement pallet design.
1.2.3.4	Limit PTn (Paintbrush tuff nonwelded) Temperature	Independent of drip shield and emplacement pallet design.
1.2.3.5	Limit Differential Uplift of TSw1 (Topopah Spring welded unit 1-lithophysal rich)	Independent of drip shield and emplacement pallet design.
1.2.3.6	Limit Differential Uplift of Ground Surface	Independent of drip shield and emplacement pallet design.
1.2.4.2	Provide Physical Supports for Maximum of 11,000 WPs	Independent of drip shield and emplacement pallet design.
1.2.4.3	Accommodate WP Maximum Surface Dose	TSPA to show compliance. Outside of the scope of this analysis.
1.2.4.8	Accommodate 81-m Drift Spacing	Independent of drip shield and emplacement pallet design.
1.2.4.10	Emplacement Area Within Characterized Area	Independent of drip shield and emplacement pallet design.
1.2.4.13	Accommodate Carbon Steel Ground Support	TSPA to show compliance. Outside of the scope of this analysis.
1.2.4.14	Maintain Emplacement Drift Near Field Environment	Independent of drip shield and emplacement pallet design.
1.2.4.15	Accommodate Invert Placement	Independent of drip shield and emplacement pallet design.
1.2.4.16	System Located 200 m Below Ground Surface	Independent of drip shield and emplacement pallet design.
1.2.5.1	The drip shield shall be designed to achieve a minimum reliability during the first 10,000 years after emplacement in an emplacement drift.	TSPA to show compliance. Outside of the scope of this analysis.
1.2.6.1	Design of Steel SSCs in Accordance With “Manual of Steel Construction Allowable Stress Design” or “Manual of Steel Construction Load and Resistance Factor Design”	Does not apply to drip shield or emplacement pallet design.
1.3	Subsystem Design Criteria	No such criteria are identified.

Source: CRWMS M&O 2000k

4.2.1.1 System Performance Criteria

The applicable System Performance Criteria for the Emplacement Drift SDD (CRWMS M&O 2000k) are listed in Table 3. In this table, the column denoted as "SR/LA" indicates the time frame during which the compliance of the criterion will be demonstrated. For those denoted as "SR", the demonstration will occur during Site Recommendation activities. For those denoted as "LA", the first demonstration will not occur until License Application activities have commenced.

Table 3. Summary of System Performance Criteria in Emplacement Drift SDD

SDD Section	Summary of Criteria	SR/LA	Comments
1.2.1.3	The system shall limit the emplacement drift wall temperature to 96 EC or less during the preclosure period.	SR	Thermal Calculation
1.2.1.5	If the MGR (Monitored Geologic Repository) is closed at 125 years after emplacement of the initial waste package or later, the system shall limit the temperature of the emplacement drift walls to 96 EC or less during the postclosure period.	SR	Thermal Calculation
1.2.1.6	The system shall be designed for line loading of WPs within individual emplacement drifts.	SR	Thermal Calculation
1.2.1.13	The drip shield shall divert water dripping into the emplacement drift around the WP and to the drift floor.	SR	Design Sketch
1.2.1.14	The drip shield and backfill (as a collective unit) shall be designed to withstand a 13 MT (28,665 lb) rock (spherical geometry assumed) falling onto the top of the backfill without rupturing the drip shield or parting between the individual drip shield units.	SR/LA	Structural Calculation
1.2.1.15	The drip shield and backfill (as a collective unit) shall be designed to withstand a 13 MT (28,665 lb) rock (spherical geometry assumed) falling onto the top of the backfill without the drip shield contacting a WP.	SR/LA	Structural Calculation
1.2.1.16	The drip shield shall be designed to withstand a Category 2 design basis earthquake without rupturing or parting between individual drip shield units.	SR	Structural Calculation
1.2.1.17	The drip shield shall be designed to withstand a Category 2 design basis earthquake without contacting waste packages.	LA	Structural Calculation
1.2.1.18	The drip shield materials shall be Grade 7 Titanium, a minimum of 15 mm thick at the time of emplacement.	SR	Design Sketch
1.2.1.20	The invert and WP emplacement pallet shall maintain the WPs' nominal emplacement position for 300 years.	SR	Structural Calculation
1.2.1.21	The invert and WP emplacement pallet shall maintain the WPs' nominal horizontal emplacement position for 10,000 years after closure.	LA	Structural Calculation
1.2.1.22	The invert and WP emplacement pallet shall provide structural support for the SSCs as identified in Table I-2[a].	SR	Structural Calculation

NOTE: [a]Table I-2 of CRWMS M&O 2000k

4.2.1.2 Safety Criterion

The applicable Safety Criterion for the Emplacement Drift SDD (CRWMS M&O 2000k) is listed in Table 4.

Table 4. Summary of Safety Criterion in Emplacement Drift SDD

SDD Section	Summary of Criterion	SR/LA	Comments
1.2.2.1.2	For 10,000 years after permanent closure, criticality events due to fissionable material released from a breached WP shall not increase the total radionuclide inventory of the MGR by more than 1 percent. The percentage radionuclide inventory increase for the MGR shall be measured by the sum of the products of probability of criticality, multiplied by the radionuclide inventory increment (measured in curies) due to that criticality, divided by the radionuclide inventory of the MGR, with the sum taken over time and any other parameters that characterize the occurrence of criticality. Both the radionuclide inventory and the increment due to criticality shall be evaluated at the instant 1,000 years following the criticality shutdown.	SR	Criticality calculation of entire system, not specific to drip shield or emplacement pallet.

4.2.1.3 System Environment Criteria

The applicable System Environment Criteria for the Emplacement Drift SDD (CRWMS M&O 2000k) are listed in Table 5.

Table 5. Summary of System Environment Criteria in Emplacement Drift SDD

SDD Section	Summary of Criteria	SR/LA	Comments
1.2.3.1	The system shall limit the emplacement drift wall temperature to less than 200 EC during the postclosure period.	SR	Thermal Calculation
1.2.3.7	The portions of the system designed to withstand a Frequency Category 2 design basis earthquake shall be designed using the input parameters defined in Tables I-3 through I-6[a].	SR	Structural Calculation
1.2.3.8	Values representing the initial condition of the Natural Barrier shall be obtained from the Technical Data Management System (TDMS)	LA	Thermal Calculations

NOTE: [a]Tables I-3 through I-6 of CRWMS M&O 2000k

4.2.1.4 System Interfacing Criteria

The applicable System Interfacing Criteria for the Emplacement Drift SDD (CRWMS M&O 2000k) are listed in Table 6.

Table 6. Summary of System Interfacing Criteria in Emplacement Drift SDD

SDD Section	Summary of Criteria	SR/LA	Comments
1.2.4.1	The system shall be designed in accordance with the interface agreement defined in “Interface Control Document For Waste Packages and the Mined Geologic Disposal System Repository Subsurface Facilities and Systems For Mechanical and Envelope Interfaces” (CRWMS M&O 1998)	LA	Design Sketch
1.2.4.4	The system shall accommodate a maximum WP thermal output of 11.8 kW at the time of emplacement.	SR	Thermal Calculation
1.2.4.5	The system shall accommodate removal of 70 percent of the heat generated by WPs by the Subsurface Ventilation System during the preclosure period.	LA	Thermal Calculation
1.2.4.6	The system shall provide for horizontal in-drift emplacement of WP Emplacement Pallets holding WPs within emplacement drifts by the Waste Emplacement/Retrieval System.	SR	Design Sketch
1.2.4.7	The system shall accommodate a minimum spacing of 10 cm between WPs within individual emplacement drifts.	SR/LA	Structural Calculation for SR/LA and Thermal Calculation for SR
1.2.4.9	The system shall accommodate a nominal emplacement drift excavated diameter of 5.5 m.	SR	Design Sketch
1.2.4.11	The system shall accommodate the mobile equipment operating and coupon placement envelopes identified in “Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift” (CRWMS M&O 1999a).	LA	Design Sketch
1.2.4.12	The materials that contact the surface of the WPs, as emplaced during the preclosure period, shall be the same material as the WP outer surface.	SR	Design Sketch

4.2.1.5 Operational Criteria

There are no applicable Operational Criteria.

4.2.1.6 Codes and Standards Criterion

The applicable Codes and Standards Criterion for the Emplacement Drift SDD (CRWMS M&O 2000k) is listed in Table 7.

Table 7. Summary of Codes and Standards Criterion in Emplacement Drift SDD

SDD Section	Summary of Criterion	SR/LA	Comments
1.2.6.2	The system shall comply with the applicable assumptions contained in the “Monitored Geologic Repository Project Description Document” (CRWMS M&O 1999b).	SR	Assessment of Assumptions

4.2.2 Criteria From Other SDDs

The criteria in Table 8 come from the *Uncanistered Spent Nuclear Fuel Disposal Container System Description Document* (CRWMS M&O 1999e), the *Defense High Level Waste Disposal*

Container System Description Document (CRWMS M&O 1999f), and the *Naval Spent Nuclear Fuel Disposal Container System Description Document* (CRWMS M&O 1999g). These criteria, while not directly specified for the emplacement pallets, should be applied since the emplacement pallet is being used for lifting of the waste package. Future revisions to the *Emplacement Drift System Description Document* (CRWMS M&O 2000k) should include these criteria.

Table 8. Summary of Criteria from Other SDDs

SDD Section	Summary of Criteria	SR/LA	Comments
1.2.1.8 (CRWMS M&O 1999e) 1.2.1.9 (CRWMS M&O 1999f) 1.2.1.6 (CRWMS M&O 1999g)	The disposal container/waste package shall be designed to support/allow retrieval up to 300 years after the start of emplacement operations.	SR	Structural Calculation for Emplacement Pallet
1.2.1.16 (CRWMS M&O 1999e) 1.2.1.16 (CRWMS M&O 1999f) 1.2.1.12 (CRWMS M&O 1999g)	Lifting features of the disposal container/waste package shall be designed for three times the maximum weight of the loaded and sealed disposal container without generating a combined shear stress or maximum tensile stress in excess of the corresponding minimum tensile yield strength of the materials of construction.	SR	Structural Calculation for Emplacement Pallet
1.2.1.17 (CRWMS M&O 1999e) 1.2.1.17 (CRWMS M&O 1999f) 1.2.1.13 (CRWMS M&O 1999g)	Lifting features of the disposal container/waste package shall be designed for five times the weight of the waste package without exceeding the ultimate tensile strength of the materials.	SR	Structural Calculation for Emplacement Pallet

4.2.3 Additional Criterion

There is an additional criterion, given in Table 9, that is taken from the *Waste Package Design Sensitivity Report* (CRWMS M&O 2000b). This criterion should be added to the *Emplacement Drift System Description Document* (CRWMS M&O 2000k) as compliance with it is needed to show long-term performance of the drip shield.

Table 9. Summary of Additional Criterion

Criterion #	Summary of Criterion	SR/LA	Comments
Structural-4	Drip shield must be capable of withstanding the static loads from rock from drift collapse without exceeding 20 percent of the yield strength of the drip shield materials in order to prevent the initiation of stress corrosion cracking.	SR	Structural Calculation

4.3 CODES AND STANDARDS

ANSI N14.6-1993, *American National Standard for Radioactive Materials – Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More* .

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5. ASSUMPTIONS

No assumptions were made in this analysis.

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6. ANALYSIS/MODEL

This section contains no discussion of alternate methods, as there are no alternate methods that are considered applicable. This analysis does not provide estimates of any of the factors for the Post-Closure Safety Case or Potentially Disruptive Events, and is, therefore, assigned Level 3 importance.

6.1 DRIP SHIELD

6.1.1 Design Description

An isometric view of the drip shield can be seen in Figure 1. Dimensions for the drip shield are given on an engineering sketch provided in Attachment II, Figure II-1. The interfaces between the drip shield and the waste package, emplacement pallet, invert, and ground support are shown in Attachment II, Figure II-2. The drip shield is fabricated from titanium Grade 7 plates for long-term diversion of dripping water, titanium Grade 24 structural members for long-term structural support, and feet made of Alloy 22 to prevent direct contact between the titanium and the steel members in the invert (CRWMS M&O 2000j, Figure 6), which could result in hydrogen embrittlement of the titanium. All of the titanium components will be assembled by welding. The Alloy 22 feet will be connected by mechanical means since Alloy 22 and titanium cannot be welded together.

The drip shield sections will be uniformly sized, such that one design will be used over all waste package types. The drip shield sections will be interlocking, see Figure 2, to prevent separation between sections. The minimum lift height required to interlock the drip shield segments is at least 1.2 meters for clearance between the two drip shield segments, still requiring precise placement, see Figure 3. If additional clearance is required, an increase in lift height or modifications to the design will be required.

Figure 1. Drip Shield Isometric View

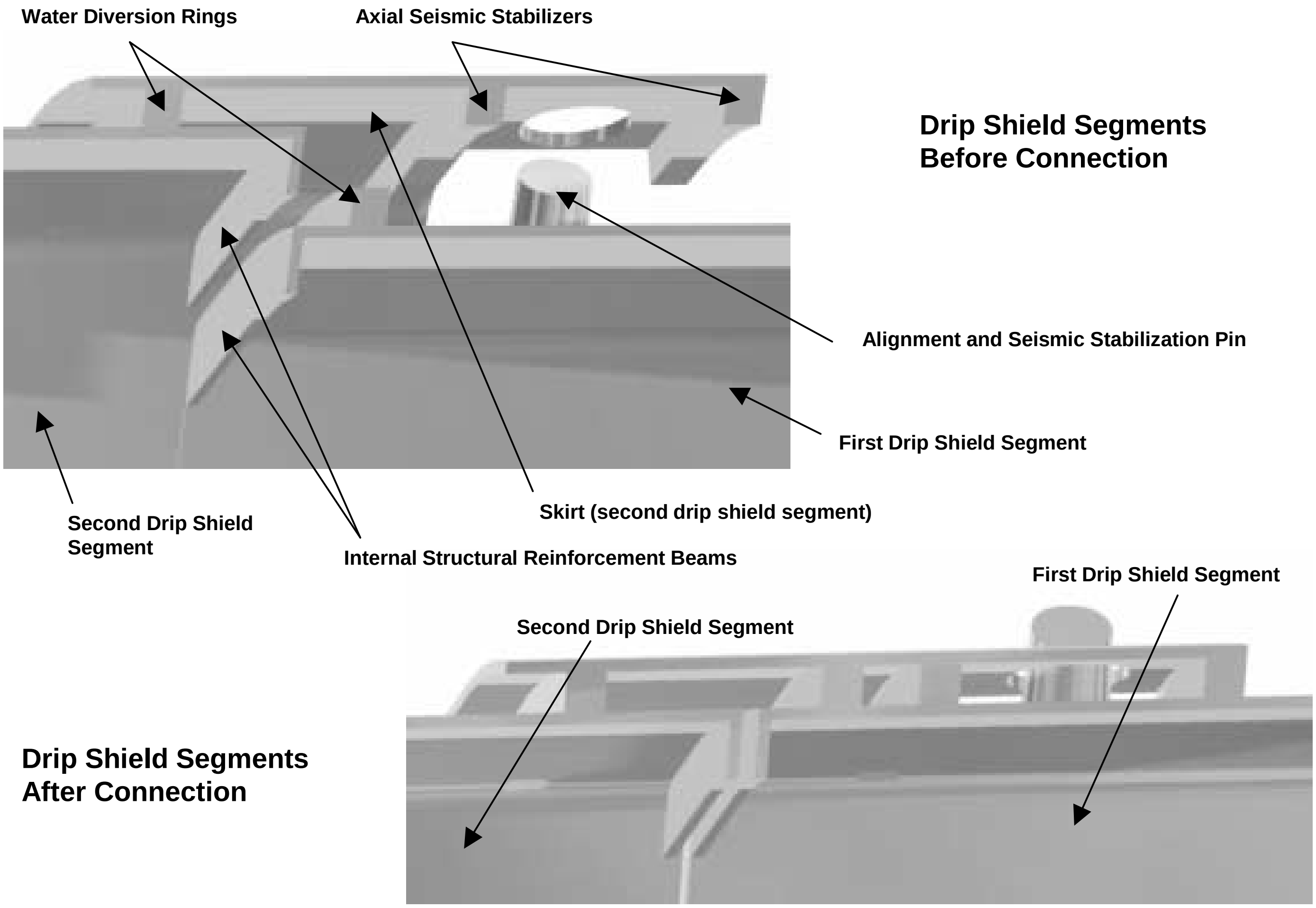


Figure 2. Drip Shield Interlocking Connection

6.1.2 Satisfaction of Criteria

6.1.2.1 System Performance Criteria

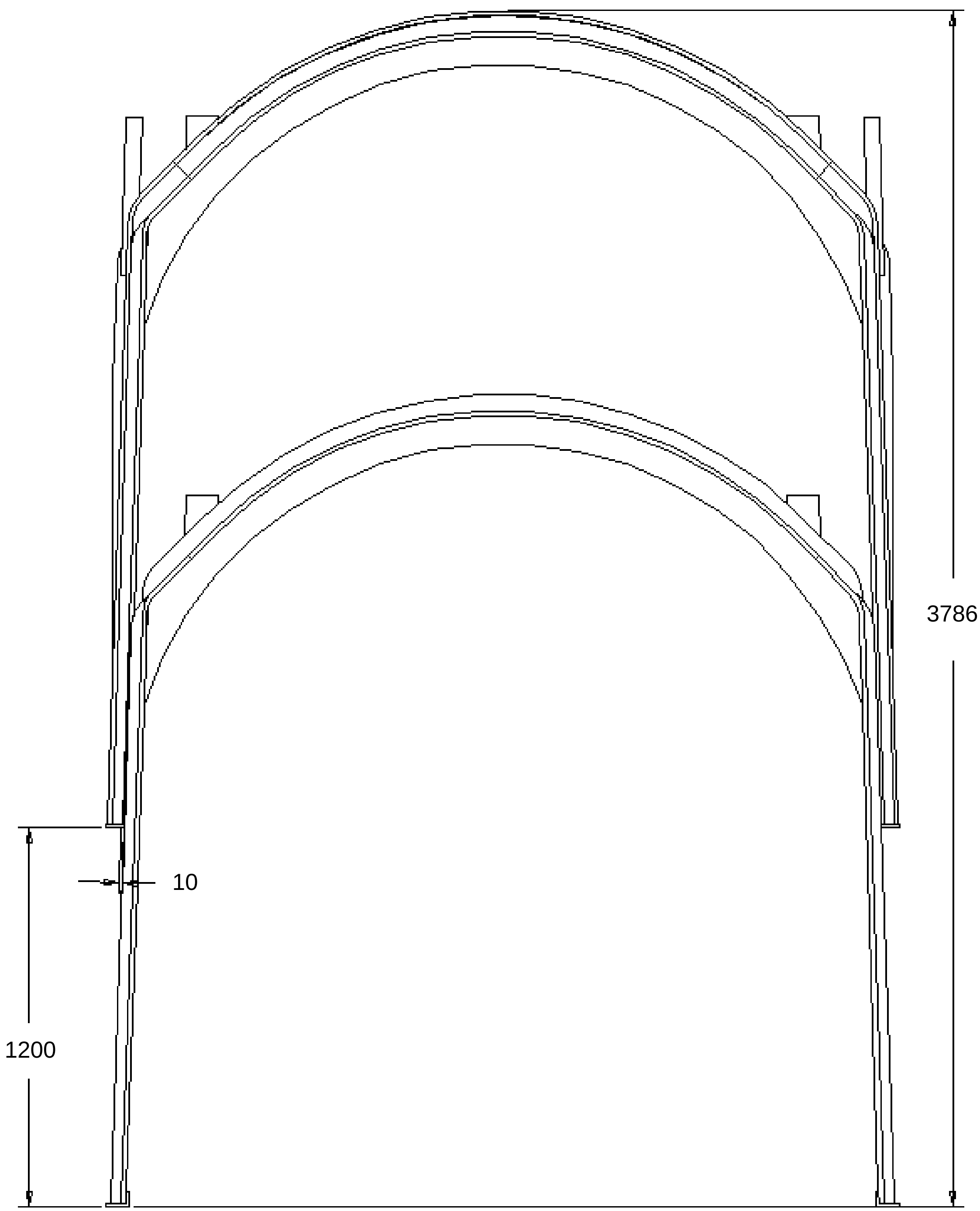
6.1.2.1.1 Limit Emplacement Drift Wall Temperature to 96 EC During Preclosure Period (1.2.1.3, CRWMS M&O 2000k)

Drift Scale Thermal Analysis (CRWMS M&O 2000g) performs a composite evaluation of repository design scenarios that were considered for resolution. These results are addressed in Section 6.6.

6.1.2.1.2 Limit Emplacement Drift Wall Temperature to 96 EC During Postclosure Period (1.2.1.5, CRWMS M&O 2000k)

This criterion will not be addressed for Site Recommendation. The recent resolution of the repository design will require a future revision of this criterion. *Drift Scale Thermal Analysis*

(CRWMS M&O 2000g) performs a composite evaluation of repository design scenarios that were considered for resolution. These results are addressed in Section 6.6.



NOTE: Dimensions in mm

Figure 3. Lift Height for Drip Shield Interlock

6.1.2.1.3 System Designed for Line Loading (1.2.1.6, CRWMS M&O 2000k)

Line-loaded waste package emplacement is imposed by management direction (CRWMS M&O 2000k, Appendix A, Section 1.2.4.7). The repository thermal design must ensure that such a thermal loading, in conjunction with the balance of the Engineered Barrier System and natural system, will not result in exceeding the peak-drift wall temperature criterion. Section 6.6 quantifies the relationship between waste package skirt-to-skirt spacing and drift wall surface temperature. Values in Section 6.6 are from *Drift Scale Thermal Analysis* (CRWMS M&O 2000g).

6.1.2.1.4 Drip Shield Divert Dripping Water (1.2.1.13, CRWMS M&O 2000k)

As can be seen in Attachment II, Figure II-2, an engineering sketch of the drip shield in the emplacement drift, the geometry of the drip shield is such that it will divert dripping water around the waste package and onto the emplacement drift floor. The interlock of the drip shields, see Figure 2, will also divert dripping water around waste packages at the seams between drip shield segments. The interlocking is accomplished using pins and holes, and also by using an overlapping section with connector guides.

6.1.2.1.5 Drip Shield With Backfill Resist 13-MT Rock Without Breach or Separation (1.2.1.14, CRWMS M&O 2000k)

Backfill is no longer part of the repository design (Dyer 2000); therefore, this criterion is no longer applicable. A new criterion will be developed for rock impact on the drip shield without backfill. *Rock Fall on Drip Shield* (CRWMS M&O 2000c) reports results of calculations of rock fall on drip shields with no backfill. These results are summarized in Section 6.8.

6.1.2.1.6 Drip Shield With Backfill Resist 13-MT Rock Without Contacting WP (1.2.1.15, CRWMS M&O 2000k)

Backfill is no longer part of the repository design (Dyer 2000); therefore, this criterion is no longer applicable. A new criterion will be developed for rock impact on the drip shield without backfill. *Rock Fall on Drip Shield* (CRWMS M&O 2000c) reports results of calculations of rock fall on drip shields with no backfill. These results are summarized in Section 6.8.

6.1.2.1.7 Drip Shield Withstand Earthquake Without Rupture or Separation (1.2.1.16, CRWMS M&O 2000k)

This criterion will not be addressed in this report and is, therefore, a limitation of this analysis. There is sufficient information available on the drip shield design for Site Recommendation without inclusion of the seismic calculations. Although drip shield separation has not yet been evaluated, the drip shields have been designed to interlock in order to prevent separation due to seismic ground motion, as can be seen in Figure 2.

6.1.2.1.8 Drip Shield Withstand Seismic Load Without Contacting Waste Packages (1.2.1.17, CRWMS M&O 2000k)

This criterion will not be addressed for Site Recommendation. It is unclear at this time whether it is necessary to prevent contact between the waste packages and the drip shields during seismic loads. If it is determined that this is a valid criterion, these calculations will be performed for License Application.

6.1.2.1.9 Drip Shield Made of 15-mm Thick Grade 7 Titanium (1.2.1.18, CRWMS M&O 2000k)

This thickness is defined for long term performance based on corrosion. This criterion is fulfilled by making the plates that divert dripping water out of 15 mm thick titanium Grade 7; see material callout and thickness for these components in Attachment II, Figure II-1. Confirmation that this material grade and thickness are sufficient for normal operating conditions can be found in the *Structural Calculations of the Drip Shield Statically Loaded by the Backfill and Loose Rock Mass* (CRWMS M&O 2000e) which is summarized in Section 6.3. Titanium Grade 24 is selected for the structural components of the drip shield because of its superior strength when compared to titanium Grade 7. The dimensions of the titanium Grade 24 structural components can be seen in Attachment II, Figure II-1.

6.1.2.2 Safety Criterion

The drip shield is not evaluated against any Safety Criteria. The entire emplacement drift system is, however, included in the criticality evaluations that will demonstrate compliance to criterion 1.2.2.1.2 of CRWMS M&O 2000k. The criticality analysis methodology is described in (CRWMS M&O 2000a, Sections 4.1.5, 5.5, and 6.5) and provides details of how compliance to this criterion will be attained.

Criticality evaluations considering the emplacement drift system are identified as near-field. The near-field evaluations include consideration of all materials that can exist external to the waste package, and near it, of which the drift invert and the drip shield will be a part. Near-field criticality calculations will be performed for each type of waste package/waste form. Some near-field criticality calculations have been performed for the plutonium disposition waste form in CRWMS M&O 2000h, with a brief description provided in Section 6.7.

6.1.2.3 System Environment Criteria

6.1.2.3.1 Limit Emplacement Drift Wall Temperature to Less Than 200 EC During the Postclosure Period (1.2.3.1, CRWMS M&O 2000k)

Drift Scale Thermal Analysis (CRWMS M&O 2000g) performs a composite evaluation of repository design scenarios that were considered for resolution. These results are addressed in Section 6.6.

6.1.2.3.2 Use Design Basis Earthquake Parameters (1.2.3.7, CRWMS M&O 2000k)

This criterion will not be addressed in this report and is, therefore, a limitation of this analysis. The parameters given in the SDD (CRWMS M&O 2000k, Section 1.2.3.7) are insufficient to perform the seismic analyses. There is sufficient information on the drip shield design for Site Recommendation without inclusion of the seismic calculations.

6.1.2.3.3 Obtain Values Representing Initial Condition of Natural Barrier from TDMS (1.2.3.8, CRWMS M&O 2000k)

This criterion will not be addressed for Site Recommendation. For License Application, values representing the initial condition of the Natural Barrier will be obtained from the TDMS.

6.1.2.4 System Interfacing Criteria

6.1.2.4.1 Comply With Interface Control Document (CRWMS M&O 1998) (1.2.4.1, CRWMS M&O 2000k)

As can be seen in Figure II-2 of Attachment II, the drip shield has been designed to fit within the mechanical envelope (drift, ground support, and invert in the repository subsurface facility as defined in CRWMS M&O 2000j). The emplacement drift dimensions given in CRWMS M&O 2000j are more current than those given in the *Interface Control Document For Waste Packages and the Mined Geologic Disposal System Repository Subsurface Facilities and Systems For Mechanical and Envelope Interfaces* (CRWMS M&O 1998). Currently, the clearance between the drip shield and the invert rail structure is 28 mm on each side, see Attachment II, Figure II-2. This is a tight tolerance considering potential deflection of the drip shield segment and the alignment tolerance between the invert rail and the drip shield emplacement gantry. Compliance with the ICD is planned to be demonstrated for License Application when the ICD is updated. It is planned to resolve any potential clearance issues at that time.

6.1.2.4.2 Accommodate Maximum WP Thermal Output of 11.8 kW at Time of Emplacement (1.2.4.4, CRWMS M&O 2000k)

The maximum heat output is imposed by management direction (CRWMS M&O 1999e, Appendix A, Section 1.2.4.4). The waste package thermal design must ensure that such a thermal loading, in conjunction with the balance of the Engineered Barrier System and natural system, will not result in exceeding the peak-drift wall temperature criterion. This is evaluated in CRWMS M&O 2000g and is reported in Section 6.6.

6.1.2.4.3 Accommodate Removal of 70 Percent WP Heat During Preclosure Period (1.2.4.5, CRWMS M&O 2000k)

Studies of the efficiency of drift ventilation are currently being performed. However, the results of these studies will not be available for Site Recommendation. The calculations and results are planned to be available for License Application.

6.1.2.4.4 Accommodate 5.5 m Diameter Drift (1.2.4.9, CRWMS M&O 2000k)

As can be seen in Figure II-2 of Attachment II, the drip shield has been designed to fit within a 5.5 m diameter drift, including the ground support, invert, and gantry rails. The ground support, invert, and gantry rail layout depicted in Figure II-2 are taken from CRWMS M&O 2000j.

6.1.2.4.5 Accommodate Mobile Equipment and Coupon Placement Envelopes (1.2.4.11, CRWMS M&O 2000k)

The *Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift* does not consider drip shields in the baselined design, (CRWMS M&O 1999a, p. 4, Section 6.2.E). Based on the drip shield width of 2512 mm, see Attachment II, Figure II-1, the envelope around the waste package of 2500 mm (CRWMS M&O 1999a, p. 8, Figure 2) is inadequate for a design including a drip shield. Also, the bottom of the clearance envelope above the waste package is 3240 mm above the bottom of the drift (CRWMS M&O 1999a, p. 8, Figure 2), while the top of the drip shield is 3307 mm above the bottom of the drift, see Attachment II, Figure II-2, again intruding into the clearance envelope. Therefore, as indicated in Section 5 of CRWMS M&O 1999a, the addition of the drip shield to the design requires a revision to CRWMS M&O 1999a. These issues are planned to be addressed for License Application when the *Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift* (CRWMS M&O 1999a) is revised.

6.1.2.5 Operational Criteria

The drip shield is not evaluated against any Operational Criteria.

6.1.2.6 Codes and Standards Criterion

6.1.2.6.1 Comply With Assumptions in "Monitored Geologic Repository Project Description Document" (1.2.6.2, CRWMS M&O 2000k)

The only assumption identified in the *Monitored Geologic Repository Project Description Document* (MGR PDD, CRWMS M&O 1999b) that is significant to drip shield design is Controlled Project Assumption (CPA) 039 – Enhanced Design Alternative II Design Definition for Performance Assessment, Waste Package Operations, and Engineered Barrier System Operations. The applicable portions of this assumption are as follows:

"In addition, performance assessment, Waste Package Operations, and Engineered Barrier System Operations will assume for SR that:

- the invert ballast material is crushed tuff,
- the backfill material is Overton sand,

- the free-standing drip shield is of "mailbox" shape and with uninterrupted coverage for the entire length of the emplacement drift, and

- the average heat output per waste package for pressurized water reactor commercial SNF at the time of emplacement will be 11.3 kW, and the average heat output per waste package for all waste packages at the time of emplacement will be 7.9 kW."

This assumption is consistent with the parameters used when evaluating the drip shield, with the exception that some calculations have been performed for systems that do not include backfill, based on direction provided in correspondence from the DOE (Dyer 2000). Such calculations are specifically identified as being performed with no backfill present.

6.1.2.7 Additional Criterion

6.1.2.7.1 Keep Static Stress Below 20 Percent of Yield Strength (Structural-4, CRWMS M&O 2000b)

The *Structural Calculations of the Drip Shield Statically Loaded by the Backfill and Loose Rock Mass* (CRWMS M&O 2000e) verify that the long term static stresses in the drip shield components remain below 20% of the yield strength of the materials. This precaution is taken to prevent stress corrosion cracking, which could otherwise shorten drip shield operating life. See Section 6.3 for a summary of the results of the *Structural Calculations of the Drip Shield Statically Loaded by the Backfill and Loose Rock Mass* (CRWMS M&O 2000e). Note that backfill is no longer part of the repository design, making the results given in CRWMS M&O 2000e conservative.

This criterion should be added to the *Emplacement Drift System Description Document* (CRWMS M&O 2000k) as compliance with it is needed to show long term performance of the drip shield.

6.2 EMPLACEMENT PALLET

6.2.1 Design Description

An isometric view of an emplacement pallet can be seen in Figure 4. Engineering sketches of the emplacement pallet designs can be seen in Figures III-1 and III-2 of Attachment III. Figure III-1 depicts the standard emplacement pallet, which is designed to be compatible with all of the waste package designs except for the 5-DHLW/DOE SNF waste package. This waste package is much shorter than the rest of the waste package designs, so it will require a shorter emplacement pallet, depicted in Figure III-2.

The emplacement pallets are fabricated from Alloy 22 plates that are welded together to form the waste package supports. Two supports are connected by square stainless steel tubing to form the completed emplacement pallet. The supports have a V-groove top surface to accept all waste package diameters. The pallet is shorter than the waste packages, such that the waste package will be supported on the outer barrier between the trunnion collar sleeves, see Figure I-1 in

Attachment I for the trunnion collar sleeve locations on a representative waste package design. The ends of the waste package will extend past the ends of the emplacement pallet, see Figure 5.

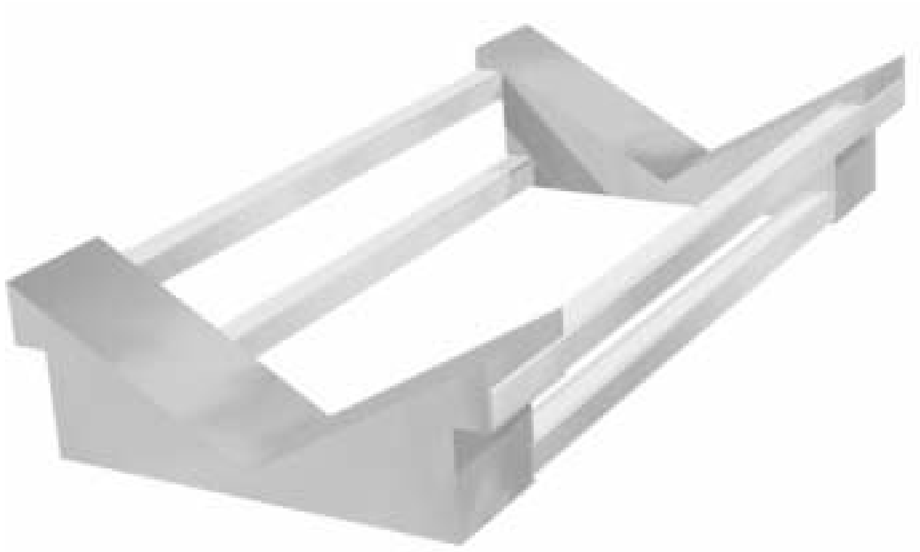


Figure 4. Emplacement Pallet Isometric View

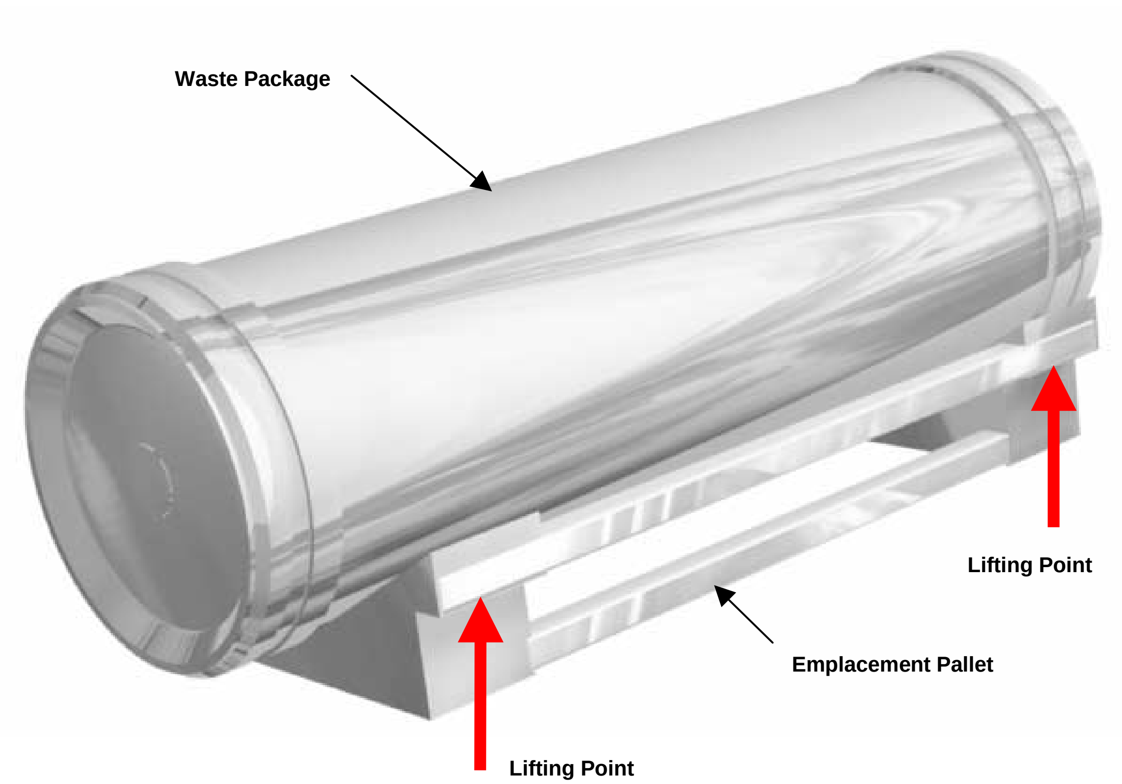


Figure 5. Emplacement Pallet Loaded with Waste Package

The emplacement pallet will be used to transport the waste package from the Waste Handling Building to the emplacement drift. The pallet will, therefore, be lifted while loaded with a waste package. The lifting points are at the support, directly under the upper stainless steel tubes, see Figure 5.

6.2.2 Satisfaction of Criteria

6.2.2.1 System Performance Criteria

6.2.2.1.1 Emplacement Pallet Shall Maintain WP Nominal Emplacement Position for 300 Years (1.2.1.20, CRWMS M&O 2000k)

This criterion is directly related to those that require the waste packages to be retrievable for up to 300 years. Supporting retrieval requires the emplacement pallet to stay in a condition that can be lifted at the end of or during the prescribed period of time. This is verified in the *Structural Calculations for the Lifting of a Loaded Emplacement Pallet* (CRWMS M&O 2000d), see Section 6.4. Calculations of the static load of a waste package on an emplacement pallet in the *Structural Calculation of an Emplacement Pallet Statically Loaded by a Waste Package* (CRWMS M&O 2000f) were performed to verify that the emplacement pallet is of sufficient strength to support a waste package for at least 300 years, see Section 6.5. Seismic activity could also affect the ability of the pallet to maintain the nominal waste package position. However, the results of seismic calcultions were not available in time to support Site Recommendation. This is identified as a limitation to this analysis. However, there is sufficient information available on the emplacement pallet design for Site Recommendation without inclusion of the seismic calculations.

6.2.2.1.2 Emplacement Pallet Shall Maintain WP Nominal Horizontal Emplacement Position for 10,000 Years (1.2.1.21, CRWMS M&O 2000k)

Horizontal movement of the waste package over 10,000 years would primarily be due to seismic activity. Seismic time histories were not available for calculations to support Site Recommendation. Any seismic response of the emplacement pallet loaded with a waste package is planned to be performed for License Application.

6.2.2.1.3 Emplacement Pallet Shall Provide Structural Support for the WP (1.2.1.22, CRWMS M&O 2000k)

The only SSC listed in Table I-2 in CRWMS M&O 2000k that is applicable for the emplacement pallet is the waste package. Calculations of the static load of a waste package on an emplacement pallet were performed in the *Structural Calculation of an Emplacement Pallet Statically Loaded by a Waste Package* (CRWMS M&O 2000f), see Section 6.5.

6.2.2.2 Safety Criterion

The emplacement pallet is not evaluated against any Safety Criteria. The entire emplacement drift system is, however, included in the criticality evaluations that will demonstrate compliance to criterion 1.2.2.1.2 of CRWMS M&O 2000k. As both the drip shield and emplacement pallet are considered part of the drift for the near-field criticality calculations, this is consistent with that which has been addressed for the drip shield, see Section 6.1.2.2.

6.2.2.3 System Environment Criteria

6.2.2.3.1 Use Design Basis Earthquake Parameters (1.2.3.7, CRWMS M&O 2000k)

This criterion will not be addressed in this report and is, therefore, a limitation of this analysis. The parameters given in the SDD (CRWMS M&O 2000k, Section 1.2.3.7) are insufficient to perform the seismic analyses. There is sufficient information available on the emplacement pallet design for Site Recommendation without inclusion of the seismic calculations.

6.2.2.3.2 Obtain Values Representing Condition of Natural Barrier from TDMS (1.2.3.8, CRWMS M&O 2000k)

This criterion will not be addressed for Site Recommendation. For License Application, values representing the initial condition of the Natural Barrier will be obtained from the TDMS.

6.2.2.4 System Interfacing Criteria

6.2.2.4.1 Comply With Interface Control Document (CRWMS M&O 1998) (1.2.4.1, CRWMS M&O 2000k)

As can be seen in Figure II-2 of Attachment II, the emplacement pallet has been designed to fit within the mechanical envelope (drift, ground support, and invert in the repository subsurface facility as defined in CRWMS M&O 2000j). The emplacement drift dimensions given in CRWMS M&O 2000j are more current than those given in the *Interface Control Document For Waste Packages and the Mined Geologic Disposal System Repository Subsurface Facilities and Systems For Mechanical and Envelope Interfaces* (CRWMS M&O 1998). Compliance with the ICD is planned to be demonstrated for License Application when the ICD has been updated.

6.2.2.4.2 Provide for Horizontal In-drift Emplacement of Waste Packages (1.2.4.6, CRWMS M&O 2000k)

Calculations of the static load of a waste package loaded horizontally on an emplacement pallet were performed in the *Structural Calculation of an Emplacement Pallet Statically Loaded by a Waste Package* (CRWMS M&O 2000f), see Section 6.5, and compliance with mechanical envelopes for horizontal in-drift emplacement is demonstrated in Attachment II, Figure II-2. Calculations of lifting of an emplacement pallet loaded with a waste package were performed in *Structural Calculations for the Lifting of a Loaded Emplacement Pallet* (CRWMS M&O 2000d), see Section 6.4. These three items demonstrate that the design is such that it provides for horizontal in-drift emplacement of the waste packages.

6.2.2.4.3 Accommodate a Minimum Spacing of 10 cm Between WPs (1.2.4.7, CRWMS M&O 2000k)

As can be seen in Figure 5, the pallet is designed to be lifted by the sides. As can also been seen, the waste package is longer than the emplacement pallet. The combination of these two features removes any physical limit for the minimum spacing between waste packages due to the emplacement pallet design.

6.2.2.4.4 Accommodate 5.5 m Diameter Drift (1.2.4.9, CRWMS M&O 2000k)

As can be seen in Attachment II, Figure II-2, the emplacement pallet has been designed to fit within a 5.5 m diameter drift, including the ground support, invert, and gantry rails.

6.2.2.4.5 Accommodate Mobile Equipment and Coupon Placement Envelopes (1.2.4.11, CRWMS M&O 2000k)

The *Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift* addresses the previous invert design and emplacement concept (CRWMS M&O 1999a, p. 8, Figure 2). Based on the emplacement pallet width of 2150 mm, see Attachment III, Figures III-1 and III-2, the envelope around the waste package of 2500 mm (CRWMS M&O 1999a, p. 8, Figure 2) is more than adequate for a design including emplacement pallets. However, as indicated in Section 6.1.2.4.5, the addition of the drip shield to the design requires a revision to CRWMS M&O 1999a. Therefore, these issues are planned to be addressed for License Application when the *Analysis of Clearance Envelopes for Emplacement Drift Operating Equipment and Space Envelopes for Test Coupons within the Emplacement Drift* (CRWMS M&O 1999a) is revised.

6.2.2.4.6 Use Same Materials as Outer Barrier for Components that Contact WP as Emplaced (1.2.4.12, CRWMS M&O 2000k)

As can be seen in Attachment III, Figures III-1 and III-2, all of the surfaces of the emplacement pallet in contact with the waste package outer barrier are Alloy 22, the same material as the waste package outer barrier (CRWMS M&O 1999e, p. 11, Section 1.2.1.4).

6.2.2.5 Operational Criteria

The emplacement pallet is not evaluated against any Operational Criteria.

6.2.2.6 Codes and Standards Criterion

6.2.2.6.1 Comply With Assumptions in "Monitored Geologic Repository Project Description Document" (1.2.6.2, CRWMS M&O 2000k)

The only assumption identified in the *Monitored Geologic Repository Project Description Document* (MGR PDD, CRWMS M&O 1999b) that is significant to emplacement pallet design is CPA 039 – Enhanced Design Alternative II Design Definition for Performance Assessment, Waste Package Operations, and Engineered Barrier System Operations. The applicable portions of this assumption are as follows:

"In addition, performance assessment, Waste Package Operations, and Engineered Barrier System Operations will assume for SR that:

- the invert ballast material is crushed tuff,
- the backfill material is Overton sand,
- the free-standing drip shield is of "mailbox" shape and with uninterrupted coverage for the entire length of the emplacement drift, and
- the average heat output per waste package for pressurized water reactor commercial SNF at the time of emplacement will be 11.3 kW, and the average heat output per waste package for all waste packages at the time of emplacement will be 7.9 kW."

This assumption, specifically that the invert ballast material is crushed tuff, is consistent with the parameters used when evaluating the emplacement pallet under static loading in CRWMS M&O 2000f.

6.2.2.7 Criteria From Other SDDs

These criteria, while not directly specified for the emplacement pallets, should be applied since the emplacement pallet is being used for lifting of the waste package. Future revisions to the *Emplacement Drift System Description Document* (CRWMS M&O 2000k) should include these criteria.

6.2.2.7.1 Retrieval for Up to 300 Years After Start of Emplacement (1.2.1.8, CRWMS M&O 1999e) (1.2.1.9, CRWMS M&O 1999f) (1.2.1.6, CRWMS M&O 1999g)

Supporting retrieval requires the emplacement pallet to stay in a condition that can be lifted at the end of, or during, the prescribed period of time. This is verified in the *Structural Calculations for the Lifting of a Loaded Emplacement Pallet* (CRWMS M&O 2000d), see Section 6.4.

6.2.2.7.2 WP Lifting Features Designed for Maximum Stress of 1/3 Yield Strength (1.2.1.16, CRWMS M&O 1999e) (1.2.1.16, CRWMS M&O 1999f) (1.2.1.12, CRWMS M&O 1999g)

Because the emplacement pallet will be used for lifting the waste package, the stresses in the pallet during lifting of a waste package must be shown to remain below 1/3 Sy. This is verified in the *Structural Calculations for the Lifting of a Loaded Emplacement Pallet* (CRWMS M&O 2000d), see Section 6.4.

6.2.2.7.3 WP Lifting Features Designed for Maximum Stress of 1/5 Tensile Strength (1.2.1.17, CRWMS M&O 1999e) (1.2.1.17, CRWMS M&O 1999f) (1.2.1.13, CRWMS M&O 1999g)

Because the emplacement pallet will be used for lifting the waste package, the stresses in the pallet during lifting of a waste package must be shown to remain below 1/5 Su. This is verified in the *Structural Calculations for the Lifting of a Loaded Emplacement Pallet* (CRWMS M&O 2000d), see Section 6.4.

6.3 DRIP SHIELD STATIC LOAD CALCULATIONS

Calculations of static loads on the drip shield were performed in the *Structural Calculations of the Drip Shield Statically Loaded by the Backfill and Loose Rock Mass* (CRWMS M&O 2000e). These calculations were performed to determine the required dimensions of drip shield components to keep the stresses below 20 percent of the yield stress in order to reduce the risk of stress corrosion cracking. The static loads applied to the drip shield are those of the backfill and the mass of rock that may be expected to collapse in the drift. It should be noted that backfill is no longer included in the repository design (Dyer 2000); thus, this calculation is conservative. All of the component dimensions evaluated are shown in Attachment II, Figure II-1. The stress results are given in Table 10. These stress values are compared to 20 percent of yield for the materials of construction to verify that stress corrosion cracking will be avoided (CRWMS M&O 2000b).

Table 10. Stress Results from Drip Shield Statically Loaded by the Backfill and Loose Rock Mass

Material	Tensile Stress Components	Tensile Stress Magnitudes (MPa)		
		Backfill Height 0.9 m	Backfill Height 1.0 m	Backfill Height 1.1 m
Titanium Grade 7 Components	Stress in vertical direction in Drip Shield Plate-2 and external support plates	53.5	54.2	54.8
	Tangential stress in Drip Shield Plate-1 and internal support plates	49.8	50.5	51.1
	Axial stress in all Titanium Grade 7 Components	50.7	51.4	52.0
Titanium Grade 24 Components	Axial (local) stress in support beams	122.4	124.2	125.9
	Tangential stress in bulkheads	57.3	59.0	61.3

Source: CRWMS M&O 2000e, Section 6

The yield strength of titanium Grade 7 is 275 MPa, see Section 4.1.2, so 1/5 of yield is 55 MPa. The yield strength of titanium Grade 24 is 828 MPa, see Section 4.1.3, so 1/5 of yield is 165.6 MPa. As can be seen in Table 10, the stresses in the drip shield due to static loading by backfill and loose rock are below 20 percent of Sy. Therefore, the drip shield can support these loads without collapsing or becoming susceptible to stress corrosion cracking.

6.4 EMPLACEMENT PALLET LIFTING/RETRIEVAL

Calculations of waste package retrieval (lifting the waste package by the pallet) were performed in the *Structural Calculations for the Lifting of a Loaded Emplacement Pallet* (CRWMS M&O 2000d). These calculations were performed to determine the required dimensions of emplacement pallet components to keep the stresses below 1/3 Sy and 1/5 Su per ANSI N14.6-1993. The emplacement pallet is loaded with the heaviest waste package design and lifted by four lift points shown in Figure 5.

All of the component dimensions evaluated are shown in Attachment III, Figure III-1 and Figure III-2. The pallet shown in Figure III-2, which differs from the design in Figure III-1 only by the lengths of the stainless steel tubes, has the same general lifting points and contact points with the waste packages, but is designed for a much lighter waste package. Therefore, critical calculations were performed with the design shown in Figure III-1. The stress results are given in Table 11. These stress values are compared to 1/3 Sy and 1/5 Su for the materials of construction to verify that the requirements of ANSI N14.6-1993 are met.

Table 11. Stress Results from Lifting an Emplacement Pallet Loaded by a Waste Package

Material	Stress (MPa)	Yield Strength (MPa)	1/3 of Yield Strength	Tensile Strength (MPa)	1/5 of Tensile Strength (MPa)
Alloy 22	96	310 (see Section 4.1.4)	103	690 (see Section 4.1.4)	138
316L SS	39	172 (see Section 4.1.1)	57.3	483 (see Section 4.1.1)	96.6

Source of Stress: CRWMS M&O 2000d, Section 6

As can be seen in Table 11, the stresses in the emplacement pallet due to lifting while loaded with a waste package are below 1/3 of the yield strength and 1/5 of the tensile strength. Therefore, the emplacement pallet can be lifted while loaded with a waste package. Also, because corrosion during the first 300 years after emplacement is negligible (0.048 mm for Alloy 22 and 0.075 mm for 316L SS, CRWMS M&O 2000d, p. 8), the pallet will also support retrieval.

6.5 EMPLACEMENT PALLET STATIC LOAD CALCULATIONS

Calculations of the static load of a waste package on an emplacement pallet were performed in the *Structural Calculation of an Emplacement Pallet Statically Loaded by a Waste Package* (CRWMS M&O 2000f). These calculations were performed to determine the required dimensions of emplacement pallet components to keep the stresses below 1/3 of the yield strength and 1/5 of the tensile strength, while under static loading, in order to remain consistent with the stress limits for lifting. The emplacement pallet is loaded with the heaviest waste package design and placed on the drift invert. All of the component dimensions evaluated are shown in Attachment III, Figure III-1. The stress results are given in Table 12 and compared against the identified limits.

Table 12. Stress Results from Emplacement Pallet Static Load Calculation

Material	Stress (MPa)	Yield Strength (MPa)	1/3 of Yield Strength	Tensile Strength (MPa)	1/5 of Tensile Strength (MPa)
Alloy 22	98	310 (see Section 4.1.4)	103	690 (see Section 4.1.4)	138
316L SS	22	172 (see Section 4.1.1)	57.3	483 (see Section 4.1.1)	96.6

Source of Stress: CRWMS M&O 2000f, Section 6

As can be seen in Table 12, the stresses in the emplacement pallet due to the static load of a waste package are below 1/3 of the yield strength and 1/5 of the tensile strength. Therefore, the emplacement pallet can support the load of a waste package for an extended period of time without failure. Stress corrosion cracking is not considered to be an issue for the emplacement pallet because the waste package is supported by vertical plates that are under compressive loads. Thus, the emplacement pallet plates would not be susceptible to stress corrosion cracking. Since corrosion during the first 300 years after emplacement is negligible (CRWMS M&O 2000d, p. 8) and stress corrosion cracking is not an issue, the pallet should continue to support the waste package throughout the period of retrieval.

6.6 DRIFT SEGMENT/DRIFT SCALE THERMAL ANALYSES

Calculations for configurations that reasonably span the expected range of repository designs are available. These calculations, performed in *Drift Scale Thermal Analysis* (CRWMS M&O 2000g), utilize a multi-scale representation of the repository, as shown in Figure 8, to evaluate near-field repository thermal profiles for various loading configurations. This representation approximates the repository as an infinitely repeating series of "pillars," extending from the top of the mountain to a plane well into the saturated zone. Layers corresponding to the stratigraphy of the mountain represent the host rock of the repository. For each of these layers, thermal transport properties (viz., temperature-dependent thermal conductivity and specific heat) appropriate to the local rock properties are used. Laterally, adiabatic surfaces are placed at the center of the rock masses between the drifts. The variability of the waste package heat-generation rates is incorporated by representing three waste packages within the drift segment of the pillar, as shown in Figure 8. The time-dependent heat-generation rates of the waste packages are adjusted to ensure that the average heat-generation rate of the drift segment is the same as that for the repository as a whole. The 21-PWR waste package bisected by the adiabatic surface assumes the design-basis heat-generation rate of 11.8 kW, as required by criterion 1.2.4.4 of CRWMS M&O 2000k. A second waste package is an average 44-BWR waste package, while a 5-DHLW waste package serves as a fulcrum, with a heat-generation rate that ensures the segment average is the same as the repository as a whole.

This calculation obtains the peak-drift wall temperatures surrounding the design basis waste package. Results from the applications of these representations are shown in Table 13 for a range of skirt-to-skirt separations (see Figures 6 and 7 for graphical depictions). For the analyses that assume the incorporation of backfill, an effective thermal conductivity of 0.2 W/m·K was used (CRWMS M&O 2000g, Section 3.2.19). Pre-closure ventilation periods of both 25 and 50 years were analyzed. This corresponds to the interval between the initial emplacement of a waste package and the final emplacement, assuming a total ventilation period of 50 years. Note that the invert abutment surface is located where the invert steel set contacts the drift wall surface.

Table 13. Temperatures for 21-PWR Design Basis Waste Package

	Pre-closure Peak Temperatures (°C)		**Post-closure Peak Temperatures (°C)**	
Skirt-to-skirt Spacing (m)	**Drift Wall Invert Abutment Surface**	**Time of Peak (Years)**	**Drift Wall Invert Abutment Surface**	**Time of Peak (Years)**
25 Years Pre-closure Ventilation with Backfill				
0.1	89[b]	15	291	35
1.0	80[b]	10	249	34
2.0	73	10	216	34
5.0	61	10	155	33
10.0	51	15	107	32
25 Year Pre-closure Ventilation without Backfill				
0.1	89[b]	15	206[a]	35
1.0	80[b]	10	175	45
2.0	73	10	149	35
5.0	61	10	106	35
10.0	51	15	83	35
50 Years Pre-closure Ventilation with Backfill				
0.1	89[b]	15	217	60
0.5	84[b]	15	202	60
1.0	80[b]	10	186	60
1.5	76	10	173	60
50 Years Pre-closure Ventilation without Backfill				
0.1	89[b]	15	155	80
0.5	84[b]	15	144	70
1.0	80[b]	10	132	70
1.5	76	10	122	70

NOTES: [a]Peak temperature occurs at drift wall top surface.
[b]Peak temperature occurs at drift wall side surface.
Source: CRWMS M&O 2000g, Section 6, Table 6-22

All cases reported in Table 13 meet the pre-closure drift wall temperature limit of 96 EC (Table 3, SDD Section 1.2.1.3). Most of the cases reported in Table 13 also meet the post-closure drift wall temperature limit of 200 EC (Table 5, SDD Section 1.2.3.1).

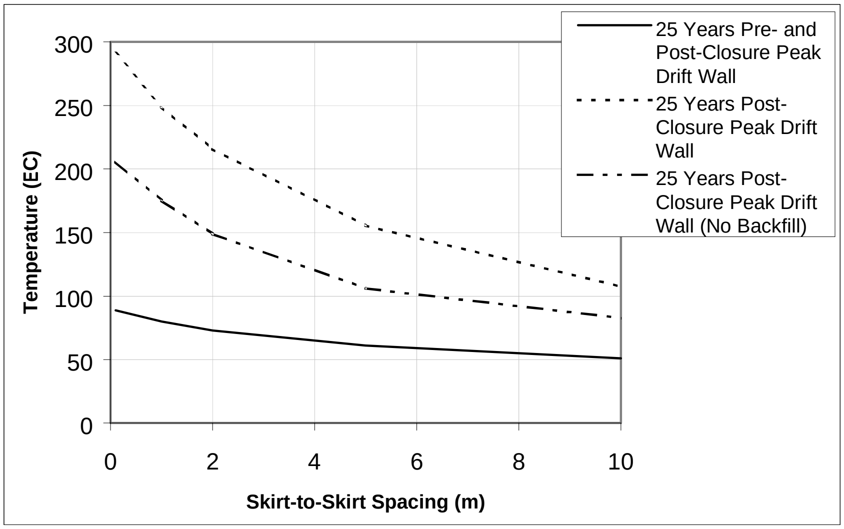


Figure 6. Pre- and Post-Closure Drift Wall Temperatures (25 years of ventilation)

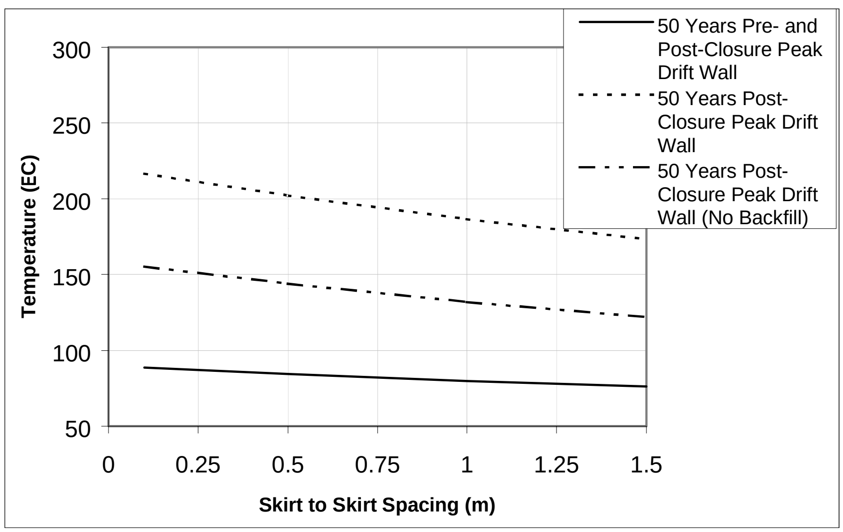


Figure 7. Pre- and Post-Closure Drift Wall Temperatures (50 years of ventilation)

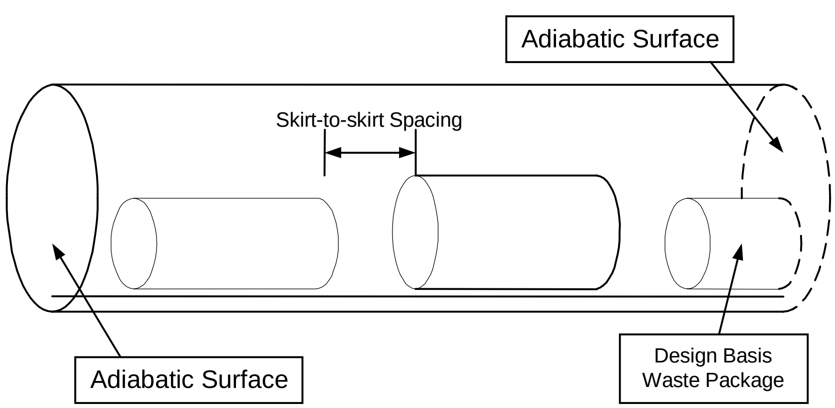


Figure 8. Drift Segment Representation

6.7 NEAR-FIELD CRITICALITY ANALYSIS

Analyses that evaluate criticality potential in the drift are considered near-field. As stated in Section 6.2.2.2, complete criticality calculations will be performed for each waste form/waste package type, of which the near-field analysis will be included.

Recent calculations have been performed for the Plutonium Disposition Waste Form (CRWMS M&O 2000h), which included some near-field criticality analyses. Criticality criterion screening calculations were performed for different near-field scenarios with the results provided in Table 14. For these evaluations, scenarios that have calculations exceeding a value for the effective neutron multiplication factor (k_{eff}) = 0.92 are considered potentially critical (i.e., the critical limit used was 0.92, CRWMS M&O 2000h, Section 6.1). From the table and the critical limit used, only the scenario represented by case 011 has the potential for criticality.

Table 14. Near-Field Criticality Evaluation of Plutonium Disposition Ceramic Waste Form

Case	Max Pu (moles/ liter void)	Max U (moles/ liter void)	Decay (years)	Corrosion Rate	Flow Concentration	Density (g/cm^3) Total Accumulation (kg)			$k_{eff} + 2\sigma$
						Pu-239	U-235	U-238	
011	0.941	Not Determined	No Decay	10x nominal	1/10th WP Footprint	0.0787 51.66	N/A	N/A	1.30923
012	0.0104	0.264	No Decay	1x nominal	WP Footprint	0.00087 5.709	N/A	N/A	0.28144
013	0.104	0.370	No Decay	1x nominal	1/10th WP Footprint	0.0087 5.709	N/A	N/A	0.89132
014	0.053	0.329	24,100	1x nominal	1/10th WP Footprint	0.0044 2.91	0.0054 3.55	0.0219 14.39	0.82168

NOTES: σ – one standard deviation.
N/A – Not determined or conservatively not represented.
Source: CRWMS M&O 2000h, Table 7-11.

Since this scenario was found to have the potential for criticality, an evaluation of the probability of the different parameters of interest to this scenario, being combined such that a potentially critical configuration would exist, was evaluated. For the probability calculation portion of the postclosure criticality methodology, a probability criterion is established consistent with having less than one criticality occurring for all combinations of waste packages and waste forms for the entire 10,000-year regulatory life of the repository (YMP 1998, Section 1.2, Item A.2). For the plutonium disposition ceramic waste form discussed as an example here, a qualitative evaluation determined that the probability of this scenario becoming potentially critical was incredible and thus was implicitly determined to meet the probability criterion.

Criticality consequences are evaluated as defense-in-depth measures for scenarios that are identified as potentially critical but meet the probability criterion. For scenarios that exceed the probability criterion, additional design features for reducing the k_{eff} are required. It is from the criticality consequence evaluations where the radionuclide increment is determined and compared against the established safety criteria such that adherence to the criteria is demonstrated. No criticality consequence calculation has yet been performed from this potentially critical scenario. It is currently believed that the resulting k_{eff} for this scenario (case

011 from above) will be reduced and will meet the criticality criterion upon reevaluation as a result of the reduction of the considered range of allowable water predicated by adherence to the emplacement drift SDD criteria 1.2.1.8. (CRWMS M&O 2000k, p. 10). This will be further evaluated and addressed in subsequent revisions to this document. With this, then all near-field scenarios will meet the criticality criterion, and no consequence evaluation will be necessary to be performed. Without any criticality consequences in the near-field, the safety criteria would be met because the radionuclide inventory increment due to criticality would be zero when it is determined no criticalities occur in the near-field for this waste form.

6.8 ROCK FALL ON DRIP SHIELD

Calculations of rock fall on drip shield were performed in the *Rock Fall on Drip Shield* (CRWMS M&O 2000c). These calculations were performed to determine what rock size, if any, would cause a crack through the drip shield. The calculations also determine the number of potential cracks and crack sizes due to stress corrosion cracking.

All of the component dimensions evaluated are shown in Attachment II, Figure II-1. The evaluations indicate no immediate failure of the drip shields due to rock falls for rocks up to 52 MT (CRWMS M&O 2000c, Section 6) for impacts with the rock either centered or off-center over the drip shield. However, the potential for stress corrosion cracking exists in the drip shield. The crack sizes and number of potential crack initiation points due to stress corrosion cracking are given in Table 15. The locations of the potential cracks are in the top plate in the vicinity of the bulkheads.

Table 15. Crack Size and Number of Potential Crack Initiation Points due to Stress Corrosion Cracking

Actual Rock Mass (MT)	Effective Rock Mass Over a 3-m Length of Drip Shield (MT)	Crack Length (cm)	Number of Potential Cracks per 3-m Partial Length of Drip Shield	Number of Potential Cracks per 6-m Full Length of Drip Shield
2	2	None	None	None
4	4	13	1	2
6	5.7	13	1	2
8	6.7	13	2	4
52	10	13	6	12

Source: CRWMS M&O 2000c, Table 6-1.

An additional rock fall simulation was performed to determine the maximum deformation in a drip shield. The geometry of the drip shield in this simulation was the same as that shown in Attachment II, Figure II-1, except that the height was increased by 200 mm. The maximum deformation is less than 170 mm (CRWMS M&O 2000c, Section 6). The clearance between the drip shield and the underlying waste package is dependent on the type of waste package, and, while this deformation exceeds the clearance between the drip shield and the 5-DHLW/DOE SNF waste package, see Attachment II, Figure II-2, the height of the drip shield can be adjusted such that contact can be avoided, as was demonstrated in CRWMS M&O 2000c by increasing the height by 200 mm.

7. CONCLUSIONS

This document may be affected by technical product input information that requires confirmation. Any changes to the document that may occur as a result of completing the confirmation activities will be reflected in subsequent revisions. The status of the input information quality may be confirmed by review of the Document Input Reference System database.

For the conclusions of this analysis, the criteria will again be identified with the section of this analysis where compliance is demonstrated.

7.1 EMPLACEMENT DRIFT SYSTEM DESCRIPTION DOCUMENT

7.1.1 System Performance Criteria

The satisfaction of emplacement drift SDD (CRWMS M&O 2000k) criteria on system performance is summarized in Table 16.

Table 16. Summary of System Performance Criteria in Emplacement Drift SDD

Section		Summary of Criteria	SR/LA	Comments
SDD	Document			
1.2.1.3	6.1.2.1.1	Limit emplacement drift wall temperature to 96 EC or less during preclosure period.	SR	Compliance Demonstrated.
1.2.1.5	6.1.2.1.2	If MGR is closed at 125 years after emplacement of initial waste package or later, limit temperature of emplacement drift walls to 96 EC or less during postclosure period.	SR	This criterion cannot be demonstrated and will need to be revised due to the recent change in the thermal design of the repository.
1.2.1.6	6.1.2.1.3	Design for line loading of WPs.	SR	Compliance Demonstrated.
1.2.1.13	6.1.2.1.4	Drip shield shall divert water around the WP.	SR	Compliance Demonstrated.
1.2.1.14	6.1.2.1.5	Drip shield and backfill shall withstand a 13 MT rock falling onto backfill without rupturing or parting between drip shield units.	SR/LA	Backfill has been removed from the system. Rock fall calculations without backfill have been performed, indicating compliance without backfill present.
1.2.1.15	6.1.2.1.6	Drip shield and backfill shall withstand a 13 MT rock falling onto backfill without drip shield contacting WP.	SR/LA	Backfill has been removed from the system. Rock fall calculations without backfill have been performed, indicating that this criterion can be met with minor modifications to the drip shield design.
1.2.1.16	6.1.2.1.7	Drip shield shall withstand a Category 2 design basis earthquake without rupturing or parting between drip shield units.	SR/LA	This is identified as a limitation of this analysis. Sufficient information on the drip shield design for Site Recommendation exists without inclusion of the seismic calculations.

1.2.1.17	6.1.2.1.8	Drip shield shall withstand a Category 2 design basis earthquake without contacting waste packages.	LA	Calculations are planned to be performed for License Application.
1.2.1.18	6.1.2.1.9	Drip shield materials shall be Grade 7 Titanium, a minimum of 15 mm thick at time of emplacement.	SR	Compliance Demonstrated.
1.2.1.20	6.2.2.1.1	Emplacement pallet shall maintain the WPs' nominal emplacement position for 300 years.	SR	Compliance demonstrated for static loading. Seismic calculations have not been performed and are a limitation of this analysis. Sufficient information on the emplacement pallet design for Site Recommendation exists without inclusion of the seismic calculations.
1.2.1.21	6.2.2.1.2	Emplacement pallet shall maintain the WPs' nominal horizontal emplacement position for 10,000 years.	LA	Dependent on seismic calculation that is planned to be performed for License Application.
1.2.1.22	6.2.2.1.3	Emplacement pallet shall provide structural support for the waste package.	SR	Compliance Demonstrated.

7.1.2 Safety Criterion

The satisfaction of the emplacement drift SDD (CRWMS M&O 2000k) criterion on safety is summarized in Table 17.

Table 17. Summary of Safety Criterion in Emplacement Drift SDD

Section		Summary of Criterion	SR/LA	Comments
SDD	Document			
1.2.2.1.2	6.1.2.2 and 6.2.2.2	For 10,000 years after permanent closure, criticality events due to fissionable material released from a breached WP shall not increase the total radionuclide inventory of the MGR by more than 1 percent.	SR	Compliance demonstrated for the evaluated waste form.

7.1.3 System Environment Criteria

The satisfaction of emplacement drift SDD (CRWMS M&O 2000k) criteria on system environment is summarized in Table 18.

Table 18. Summary of System Environment Criteria in Emplacement Drift SDD

Section		Summary of Criteria	SR/LA	Comments
SDD	Document			
1.2.3.1	6.1.2.3.1	Limit emplacement drift wall temperature to less than 200 EC during postclosure period.	SR	Compliance demonstrated for most cases evaluated in Table 13.

1.2.3.7	6.1.2.3.2 and 6.2.2.3.1	Portions of system designed to withstand a Frequency Category 2 design basis earthquake shall be designed using given input parameters.	SR	This is a limitation of this analysis. Sufficient information on the drip shield and emplacement pallet designs for Site Recommendation exists without inclusion of the seismic calculations.
1.2.3.8	6.1.2.3.3 and 6.2.2.3.2	Values representing the initial conditions of the Natural Barrier shall be obtained from the TDMS.	LA	Compliance is planned to be demonstrated for License Application.

7.1.4 System Interfacing Criteria

The satisfaction of emplacement drift SDD (CRWMS M&O 2000k) criteria on system interfacing is summarized in Table 19.

Table 19. Summary of System Interfacing Criteria in Emplacement Drift SDD

Section		Summary of Criteria	SR/LA	Comments
SDD	Document			
1.2.4.1	6.1.2.4.1 and 6.2.2.4.1	The system shall be in accordance with "Interface Control Document For Waste Packages and the Mined Geologic Disposal System Repository Subsurface Facilities and Systems For Mechanical and Envelope Interfaces" (CRWMS M&O 1998).	LA	Drip shield and emplacement pallet have both been shown to fit the mechanical clearances given in CRWMS M&O 2000j. Compliance with the ICD is planned to be demonstrated for License Application.
1.2.4.4	6.1.2.4.2	Accommodate maximum WP thermal output of 11.8 kW at emplacement.	SR	Compliance Demonstrated.
1.2.4.5	6.1.2.4.3	Accommodate removal of 70 percent of heat generated by WPs by ventilation during preclosure period.	LA	Calculations to verify the heat removal capacity are underway and are planned to be included in License Application.
1.2.4.6	6.2.2.4.2	Provide for horizontal in-drift emplacement of emplacement pallets holding WPs.	SR	Compliance Demonstrated.
1.2.4.7	6.2.2.4.3	Accommodate minimum WP spacing of 10 cm.	SR/LA	Compliance Demonstrated.
1.2.4.9	6.1.2.4.4 and 6.2.2.4.4	Accommodate a nominal emplacement drift excavated diameter of 5.5 m.	SR	Compliance Demonstrated.
1.2.4.11	6.1.2.4.5 and 6.2.2.4.5	Accommodate the mobile equipment operating and coupon placement envelopes.	LA	Demonstration of compliance with this criterion is planned to be performed for License Application.
1.2.4.12	6.2.2.4.6	Materials that contact surface of WPs shall be same as WP outer surface.	SR	Compliance Demonstrated.

7.1.5 Operational Criteria

There are no applicable Operational Criteria.

7.1.6 Codes and Standards Criterion

The satisfaction of the emplacement drift SDD (CRWMS M&O 2000k) criterion on codes and standards is summarized in Table 20.

Table 20. Summary of Codes and Standards Criterion in Emplacement Drift SDD

Section		Summary of Criterion	SR/LA	Comments
SDD	Document			
1.2.6.2	6.1.2.6.1	The system shall comply with the applicable assumptions contained in the "Monitored Geologic Repository Project Description Document" (CRWMS M&O 1999b).	SR	Compliance Demonstrated.

7.2 OTHER SYSTEM DESCRIPTION DOCUMENTS

The satisfaction of other SDD criteria is summarized in Table 21.

Table 21. Summary of Criteria from Other SDDs

Section		Summary of Criteria	SR/LA	Comments
SDD	Document			
1.2.1.8 (CRWMS M&O 1999e) 1.2.1.9 (CRWMS M&O 1999f) 1.2.1.6 (CRWMS M&O 1999g)	6.2.2.7.1	Waste package shall be retrievable up to 300 years after start of emplacement.	SR	Compliance Demonstrated.
1.2.1.16 (CRWMS M&O 1999e) 1.2.1.16 (CRWMS M&O 1999f) 1.2.1.12 (CRWMS M&O 1999g)	6.2.2.7.2	Lifting features shall be designed for three times maximum weight of loaded and sealed disposal container without generating a combined shear stress or maximum tensile stress in excess of yield strength of materials.	SR	Compliance Demonstrated.
1.2.1.17 (CRWMS M&O 1999e) 1.2.1.17 (CRWMS M&O 1999f) 1.2.1.13 (CRWMS M&O 1999g)	6.2.2.7.3	Lifting features shall be designed for five times weight of waste package without exceeding ultimate tensile strength of materials.	SR	Compliance Demonstrated.

7.3 ADDITIONAL CRITERION

The satisfaction of the additional structural criterion (CRWMS M&O 2000b) is summarized in Table 22.

Table 22. Summary of Additional Criterion

Criterion	Document Section	Summary of Criterion	SR/LA	Comments
Structural-4	6.1.2.7.1	Stress in drip shield due to static loading must not exceed 20 percent of yield strength of drip shield materials.	SR	Compliance Demonstrated.

7.4 DRIP SHIELD RECOMMENDATIONS

The drip shield design, as depicted in Figure II-1 of Attachment II, has been shown to be in compliance with all criteria for which it has been evaluated for Site Recommendation with the exception of CRWMS M&O 2000k, criterion 1.2.1.15. However, this criterion is in need of update since backfill has been removed from the design basis, and the design basis rock is being redefined. If this criterion remains for License Application, minor modifications will be needed to show compliance. The criterion listed in Table 9, which is not currently in the Emplacement Drift System Description Document (CRWMS M&O 2000k), should be added to the SDD in the next revision since it is applicable to the design of the drip shield. Future calculations are planned to be performed for the drip shield design for License Application. The criteria against which the drip shield design must be evaluated have been identified in this analysis. Revisions to the criteria should be identified in revisions to this analysis. Also, future calculations should be included in revisions to this analysis in order to identify any future design changes.

7.5 EMPLACEMENT PALLET RECOMMENDATIONS

The emplacement pallet designs, as depicted in Figures III-1 and III-2 of Attachment III, have been shown to be in compliance with all criteria for which they have been evaluated for Site Recommendation. Future calculations are planned to be performed for the emplacement pallet designs for License Application. The criteria against which the emplacement pallet designs must be evaluated have been identified in this analysis. The criteria listed in Table 8, which are not currently included in the *Emplacement Drift System Description Document* (CRWMS M&O 2000k), should be added to the SDD in the next revision since they are applicable to the design of the emplacement pallet. Revisions to the criteria should be identified in revisions to this analysis. Also, future calculations should be included in revisions to this analysis in order to identify any future design changes.

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8. INPUTS AND REFERENCES

8.1 DOCUMENTS CITED

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ATTACHMENTS

I. Waste Package Design Sketches (3 pages, for information only)

Figure I-1. *21-PWR Waste Package Configuration for Site Recommendation*, SK-0175 REV 02

Figure I-2. *21-PWR Waste Package Weld Configuration*, SK-0191 REV 00

II. Drip Shield Design Sketches (3 pages)

Figure II-1. *SR Drip Shield*, SK-0148 REV 05

Figure II-2. *Drift Cross Section Showing Emplaced Waste Package and Drip Shield*, SK-0154 REV 02

III. Emplacement Pallet Design Sketches (2 pages)

Figure III-1. *Emplacement Pallet*, SK-0144 REV 01

Figure III-2. *Short Emplacement Pallet*, SK-0189 REV 00

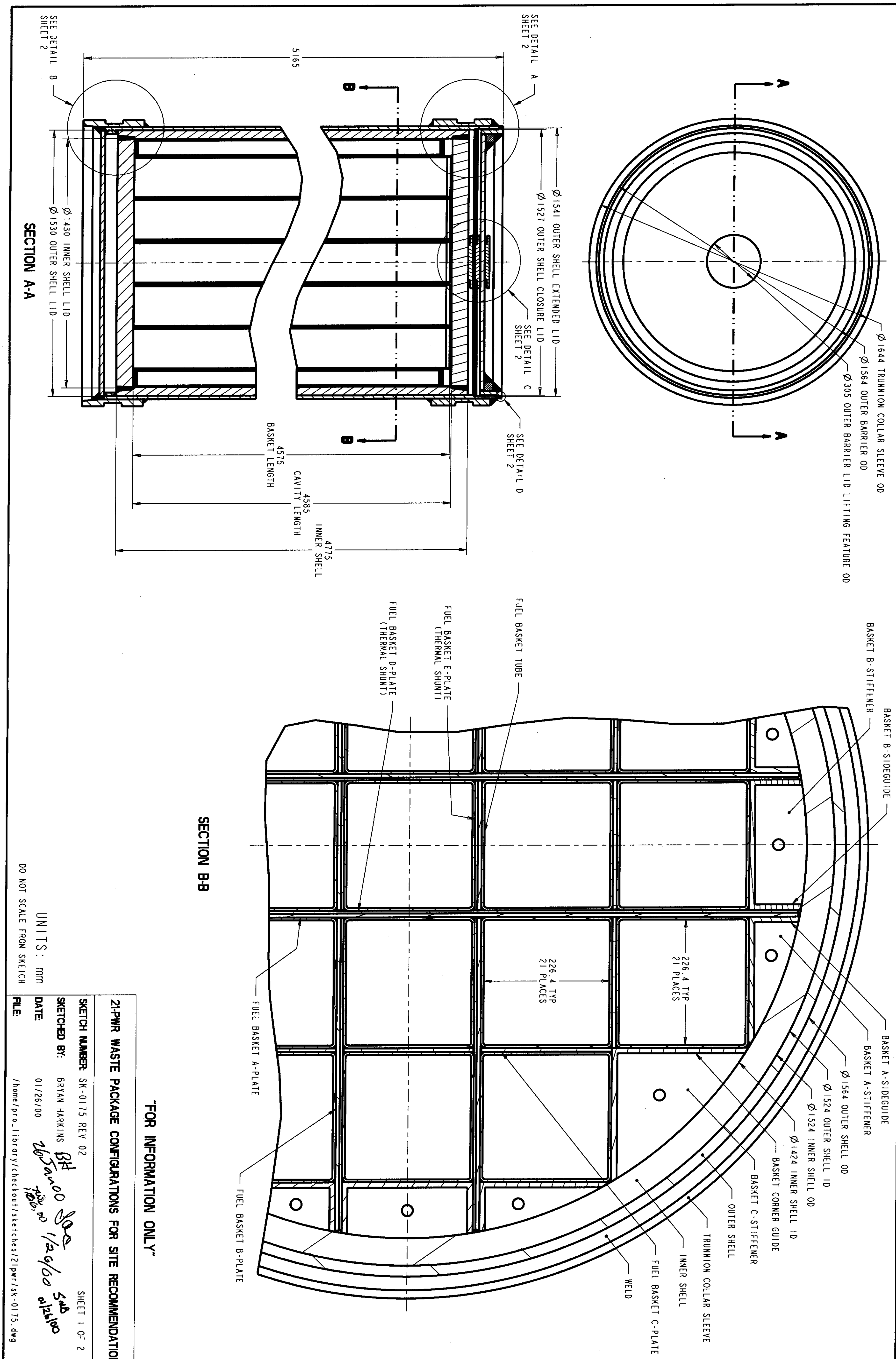
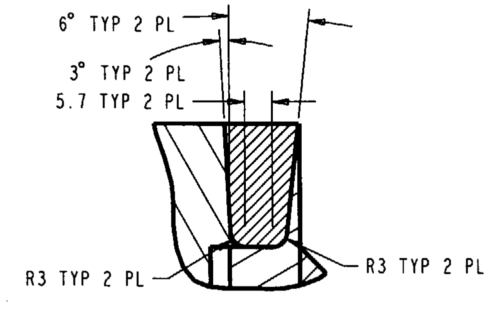
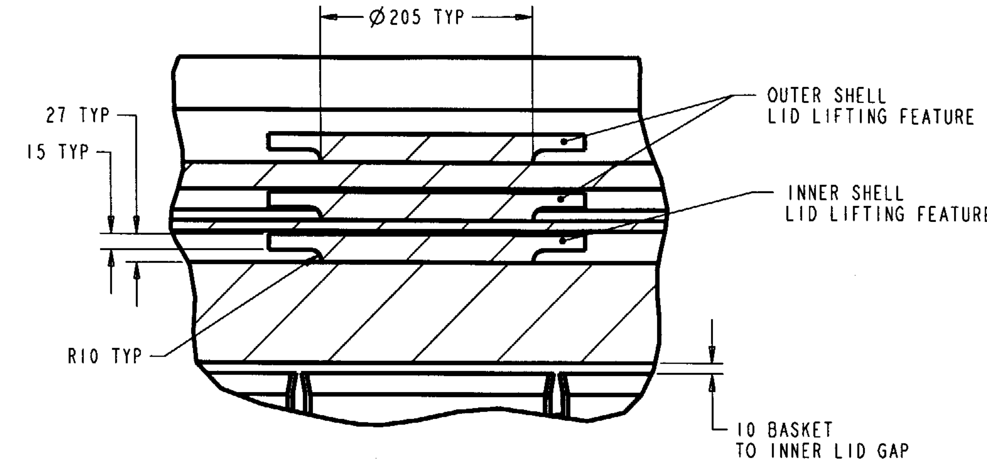


Figure I-1. 21-PWR Waste Package Configuration for Site Recommendation (Sheet 1 of 2)



DETAIL D



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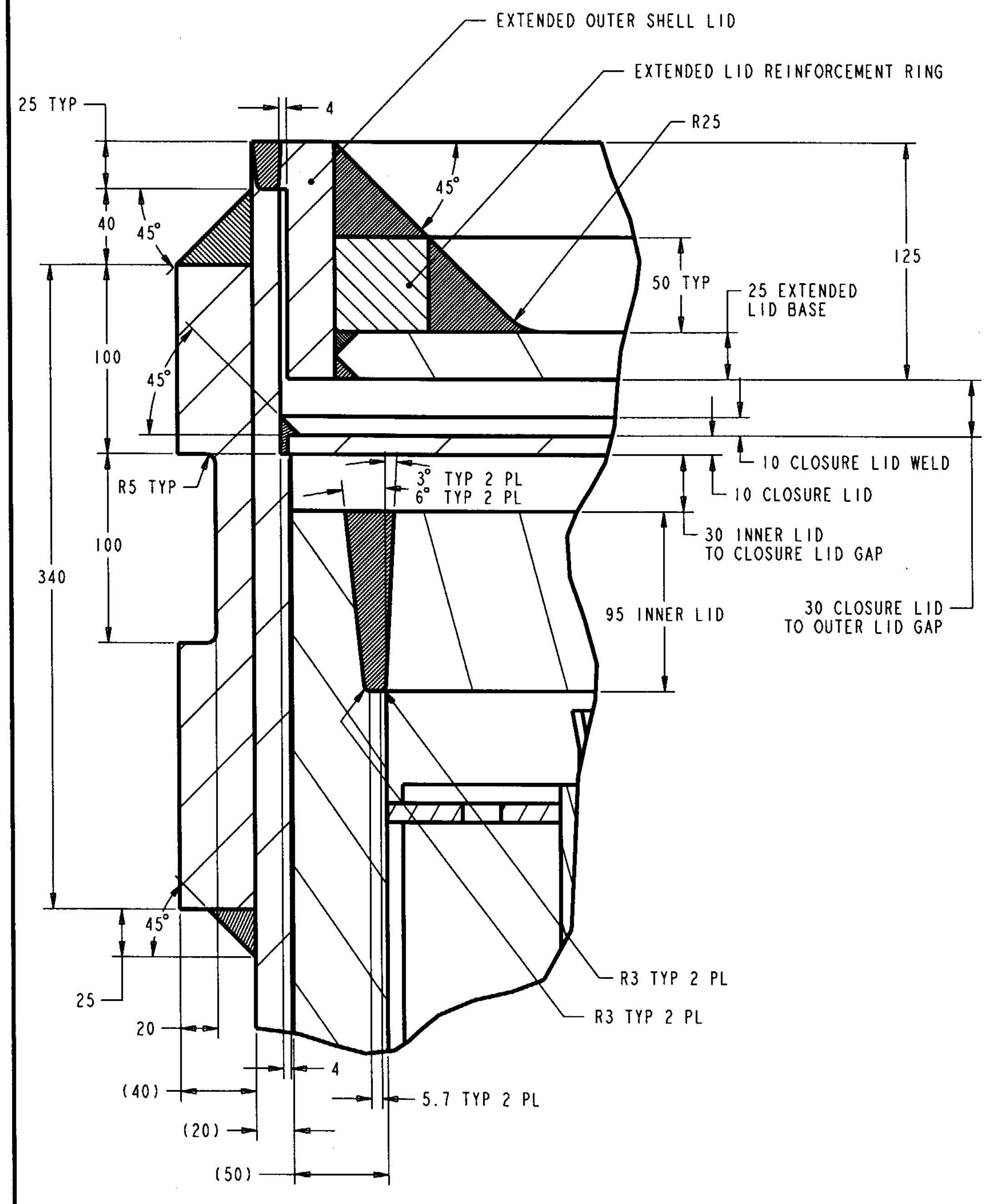


DETAIL A

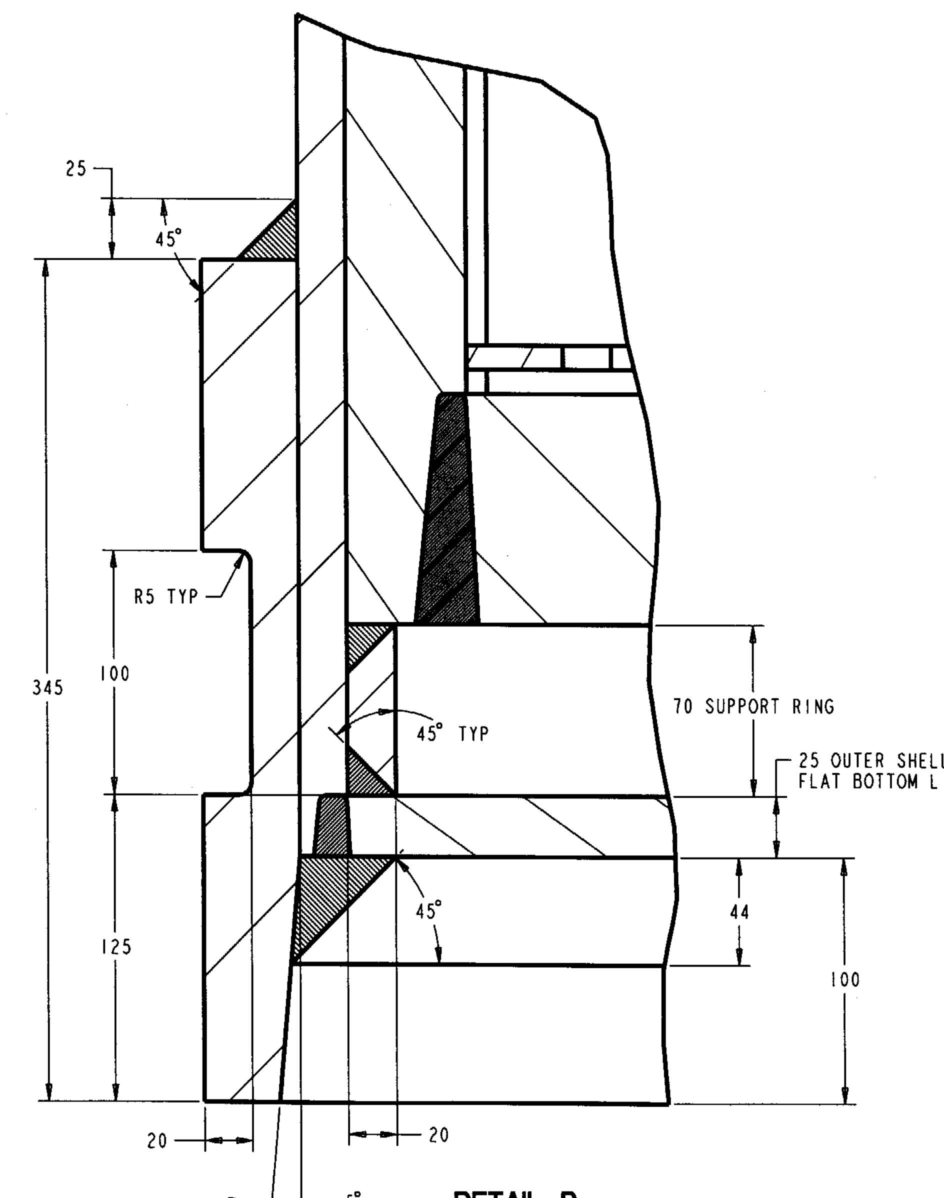
21-PWR WASTE PACKAGE ASSEMBLY WITH STAINLESS STEEL/BORON PLATES

21-PWR CONTROL ROD WASTE PACKAGE ASSEMBLY WITH CARBON STEEL PLATES

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
BASKET A-SIDEGUIDE	SA-516 K02700	10	27	32
BASKET A-STIFFENER	SA-516 K02700	10	0.72	64
BASKET B-SIDEGUIDE	SA-516 K02700	10	36	16
BASKET B-STIFFENER	SA-516 K02700	10	1.5	32
BASKET C-STIFFENER	SA-516 K02700	10	2.3	32
BASKET CORNERGUIDE	SA-516 K02700	10	42	16
FUEL BASKET A-PLATE	NEUTRONIT A 978	7	85	8
	#SA-516 K02700	#7	#86	#8
FUEL BASKET B-PLATE	NEUTRONIT A 978	7	85	8
	#SA-516 K02700	#7	#86	#8
FUEL BASKET C-PLATE	NEUTRONIT A 978	7	44	16
	#SA-516 K02700	#7	#45	#16
FUEL BASKET D-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET E-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET TUBE	SA-516 K02700	5	164	21
INNER SHELL	SA-240 S31600	50	8709	1
INNER SHELL LID	SA-240 S31600	95	1200	2
INNER LID LIFTING FEATURE	SA-240 S31600	27	12	1
OUTER SHELL	SB-575 N06022	20	4193	1
EXTENDED OUTER SHELL LID	SB-575 N06022	25	132	1
EXTENDED OUTER SHELL LID BASE	SB-575 N06022	25	366	1
OUTER LID LIFTING FEATURE	SB-575 N06022	27	13	2
EXTENDED LID REINFORCEMENT RING	SB-575 N06022	50	97	1
OUTER SHELL FLAT CLOSURE LID	SB-575 N06022	10	159	1
OUTER SHELL FLAT BOTTOM LID	SB-575 N0-6022	25	396	1
UPPER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	507	1
LOWER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	497	1
INNER SHELL SUPPORT RING	SB-575 N06022	20	41	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	-	249	**
TOTAL 316 WELDS	SFA-5.9 S31680	-	128	**
WASTE PACKAGE ASSEMBLY	-	-	26035	1
	-	-	#26059	#1
PWR FUEL ASSEMBLY	-	-	773.4*	21
WP ASSEMBLY WITH SNF	-	-	42277	1
	-	-	#42301	#1

* CRWMS M&O 1997. WASTE CONTAINER CAVITY SIZE DETERMINATION. BBAA00000-01717-0200-00026 REV 00. LAS VEGAS, NV: CRWMS M&O. ACC: MOL.19980106.0061

** REFER TO SK-0191 REV 00 "21-PWR WASTE PACKAGE WELD CONFIGURATION"

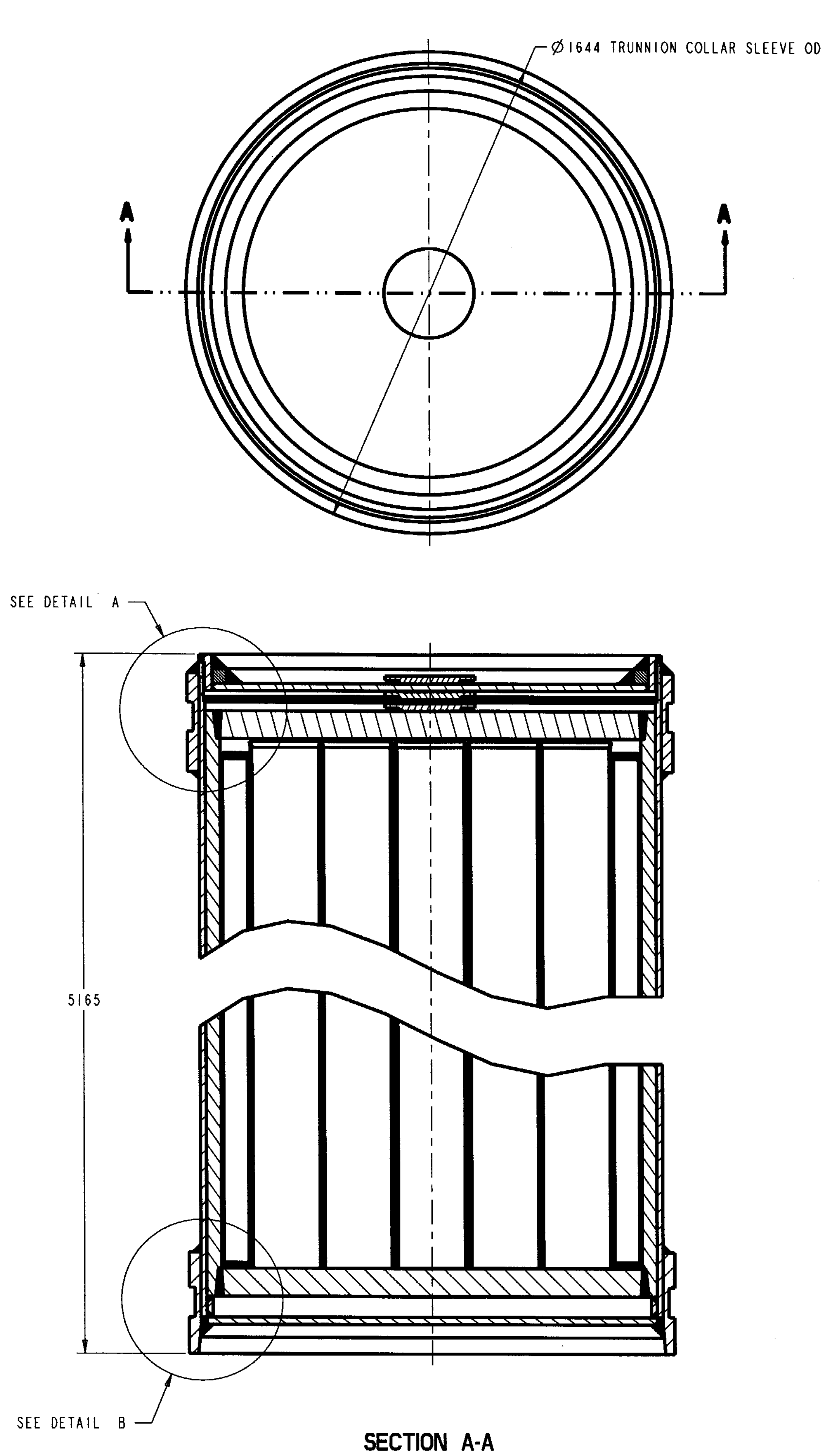


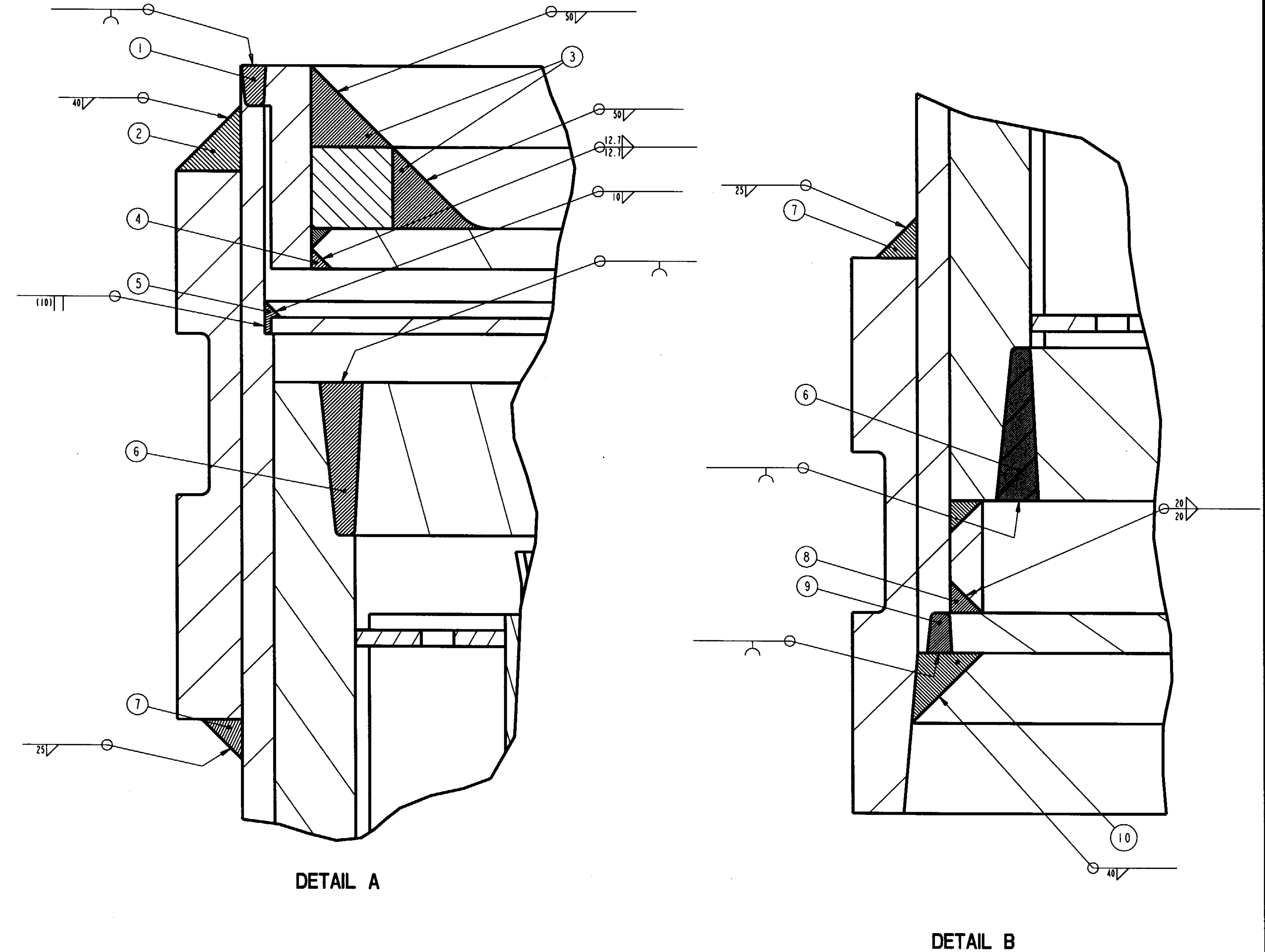
DETAIL B

02 SMB 01/27/00

SK-0175 REV ~~01~~	SHEET 2 OF 2

Figure I-1. 21-PWR Waste Package Configuration for Site Recommendation (Sheet 2 of 2)





WELD	MATERIAL	MASS (KG)	QTY RQD
1	SFA-5.14 N06022	14	1
2	SFA-5.14 N06022	35	1
3	SFA-5.14 N06022	96	1
4	SFA-5.14 N06022	3.1	2
5	SFA-5.14 N06022	3.8	1
6	SFA-5.9 S31680	64	2
7	SFA-5.14 N06022	13	2
8	SFA-5.14 N06022	8.2	2
9	SFA-5.14 N06022	14	1
10	SFA-5.14 N06022	37	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	249	-
TOTAL 316 WELDS	SFA-5.9 S31680	128	-

UNITS: mm

DO NOT SCALE FROM SKETCH

REVISIONS

REV	DESCRIPTION	DRW BY	DATE
00	ISSUED APPROVED	BH	03/09/00

"FOR INFORMATION ONLY"

21-PWR WASTE PACKAGE WELD CONFIGURATION

SKETCH NUMBER: SK-0191 REV 00

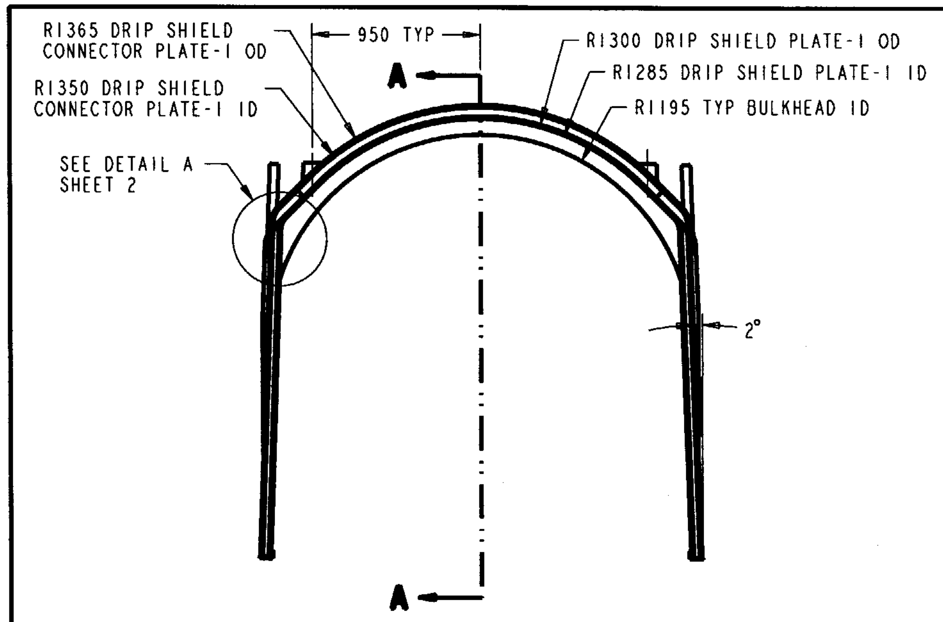
SKETCHED BY: BRYAN HARKINS

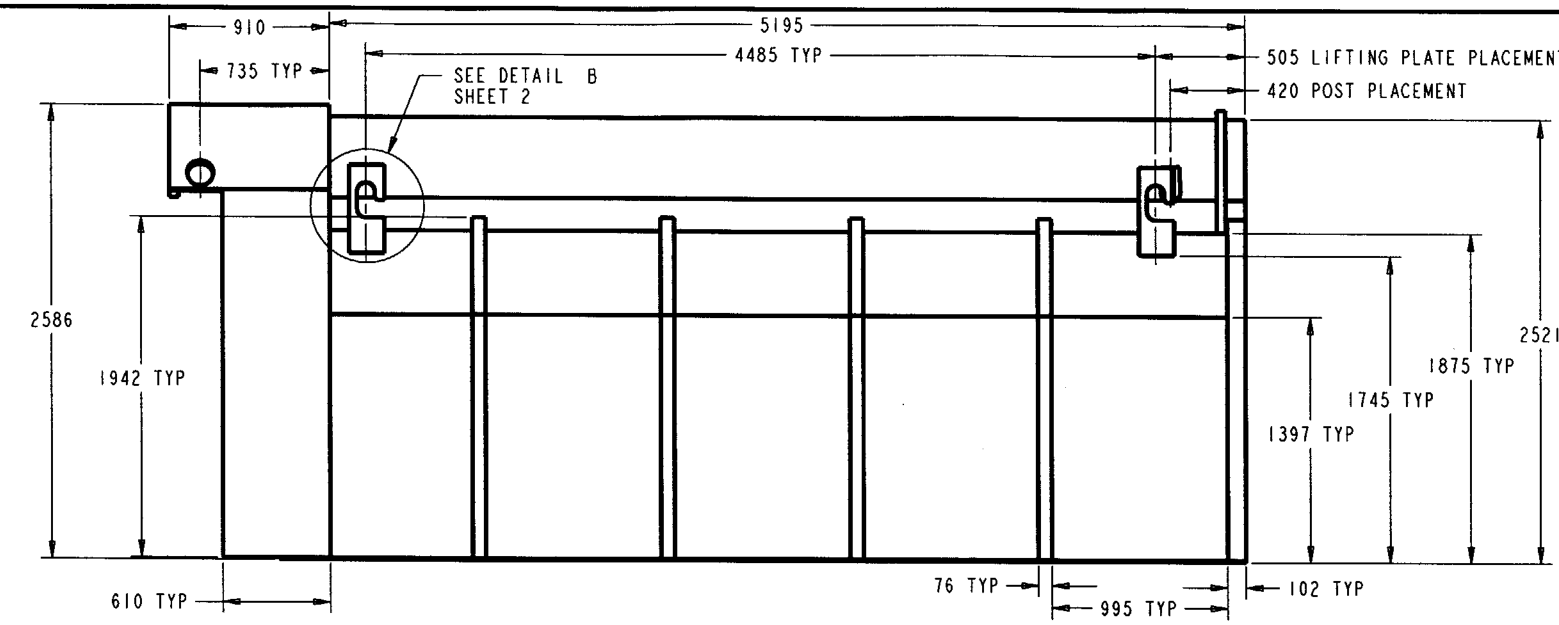
DATE: 03/09/00

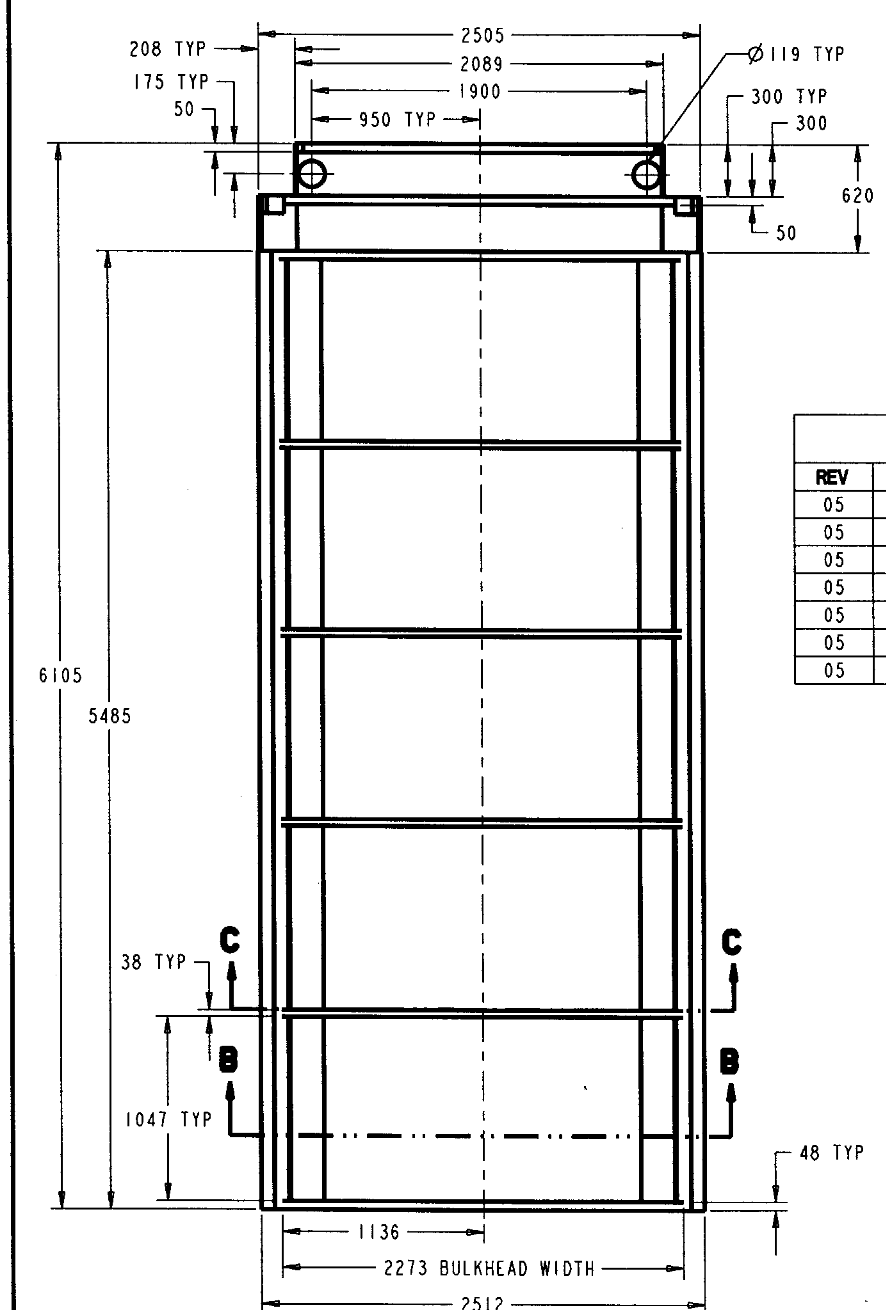
FILE: /home/pro_library/checkout/sketches/21pwr/sk-0191.dwg

BA 13March00 SMB 03/13/00 JCC 3/13/00 TGJ 3.13.00

Figure I-2. 21-PWR Waste Package Weld Configuration

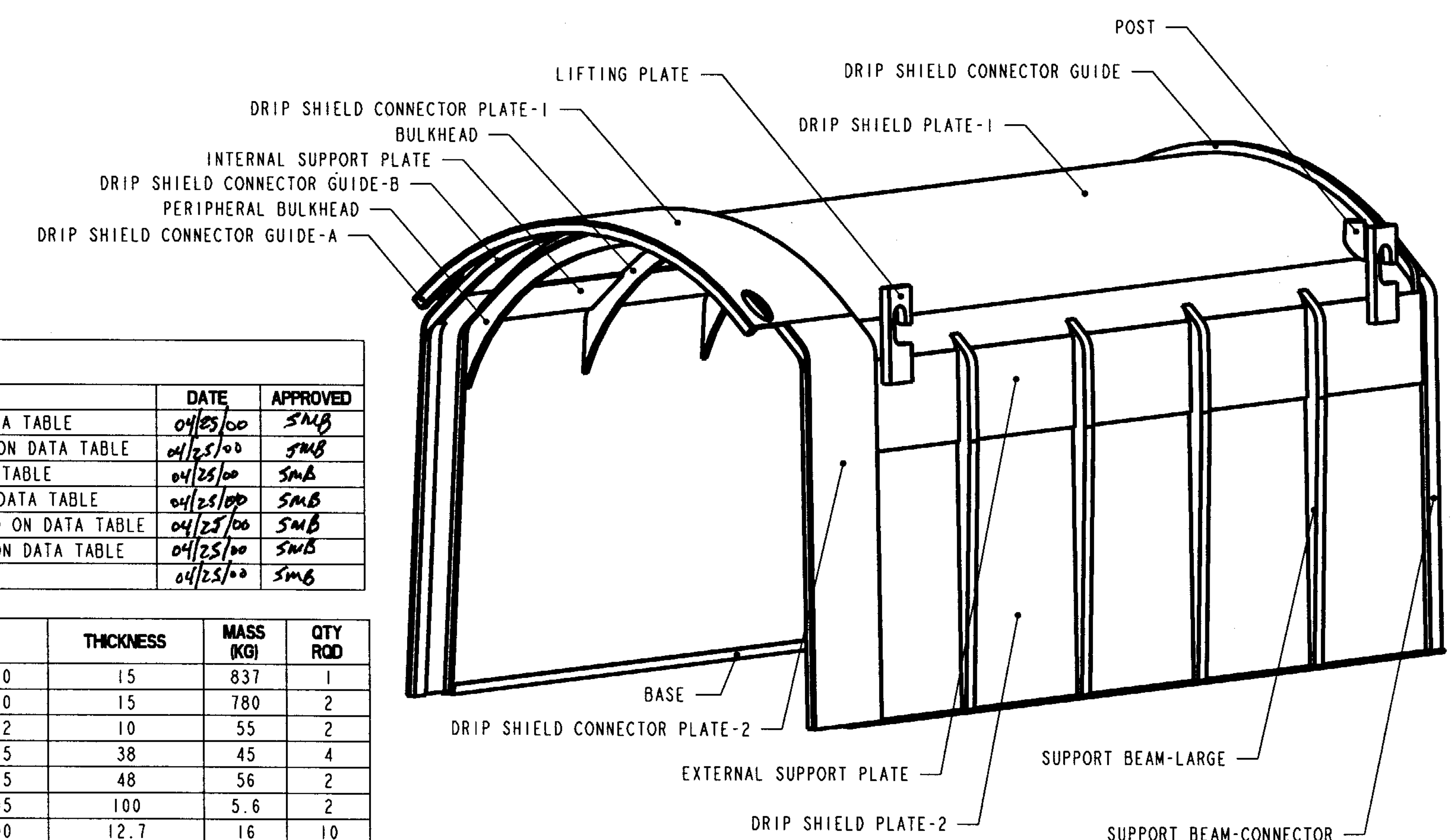






REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED
05	BULKHEAD MATERIAL UNS NUMBER CHANGED ON DATA TABLE	04/25/00	SMB
05	PERIPHERAL BULKHEAD MATERIAL UNS NUMBER CHANGED ON DATA TABLE	04/25/00	SMB
05	POST MATERIAL UNS NUMBER CHANGED ON DATA TABLE	04/25/00	SMB
05	LIFTING PLATE MATERIAL UNS NUMBER CHANGED ON DATA TABLE	04/25/00	SMB
05	SUPPORT BEAM-CONNECTOR MATERIAL UNS NUMBER CHANGED ON DATA TABLE	04/25/00	SMB
05	SUPPORT BEAM-LARGE MATERIAL UNS NUMBER CHANGED ON DATA TABLE	04/25/00	SMB
05	REVISION HISTORY TABLE ADDED	04/25/00	SMB

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY RQD
DRIP SHIELD PLATE-1	SB-265 R52400	15	837	1
DRIP SHIELD PLATE-2	SB-265 R52400	15	780	2
BASE	SB-575 N06022	10	55	2
BULKHEAD	SB-265 R56405	38	45	4
PERIPHERAL BULKHEAD	SB-265 R56405	48	56	2
POST	SB-265 R56405	100	5.6	2
INTERNAL SUPPORT PLATE	SB-265 R52400	12.7	16	10
EXTERNAL SUPPORT PLATE	SB-265 R52400	12.7	27	10
LIFTING PLATE	SB-265 R56405	50	17	4
SUPPORT BEAM-CONNECTOR	SB-265 R56405	102	27	6
SUPPORT BEAM-LARGE	SB-265 R56405	76	37	8
DRIP SHIELD CONNECTOR GUIDE	SB-265 R52400	50	30	2
DRIP SHIELD CONNECTOR PLATE-1	SB-265 R52400	15	142	1
DRIP SHIELD CONNECTOR PLATE-2	SB-265 R52400	15	89	2
DRIP SHIELD CONNECTOR GUIDE-A	SB-265 R52400	50	26	1
DRIP SHIELD CONNECTOR GUIDE-B	SB-265 R52400	50	31	1
DRIP SHIELD ASSEMBLY	-	-	4203	1



"FOR INFORMATION ONLY"

UNITS: mm
DO NOT SCALE FROM SKETCH

SR DRIP SHIELD

SKETCH NUMBER: SK-0148 REV 05 SHEET 1 OF 2
SKETCHED BY: BRYAN HARKINS BH 21April00 SMB 04/25/00 4/25/00
DATE: 04/21/00
FILE: /home/harkins/proe/drip_shield/sk-0148_rev05.dwg

Figure II-1. SR Drip Shield (Sheet 1 of 2)

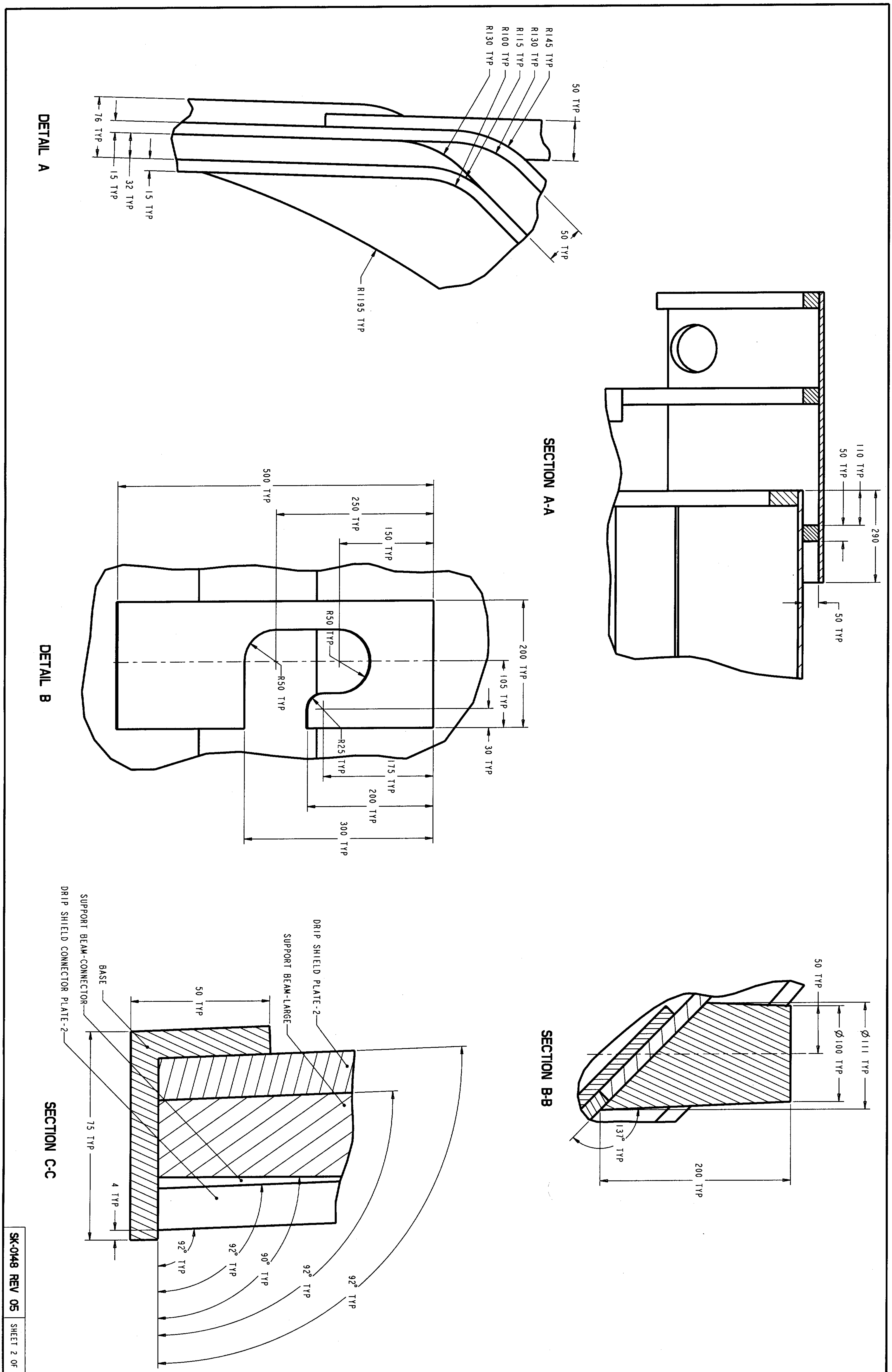


Figure II-1. SR Drip Shield (Sheet 2 of 2)

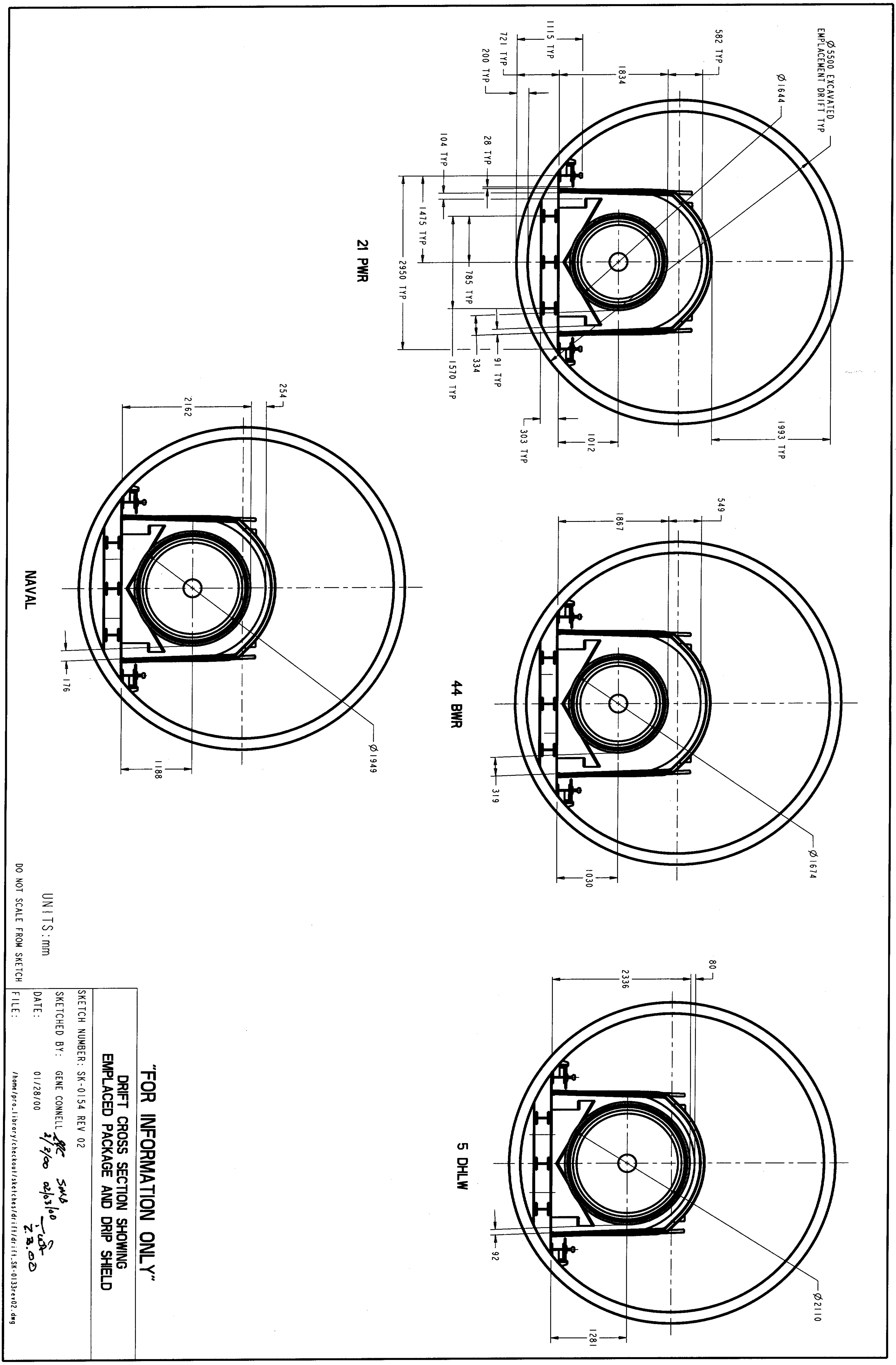
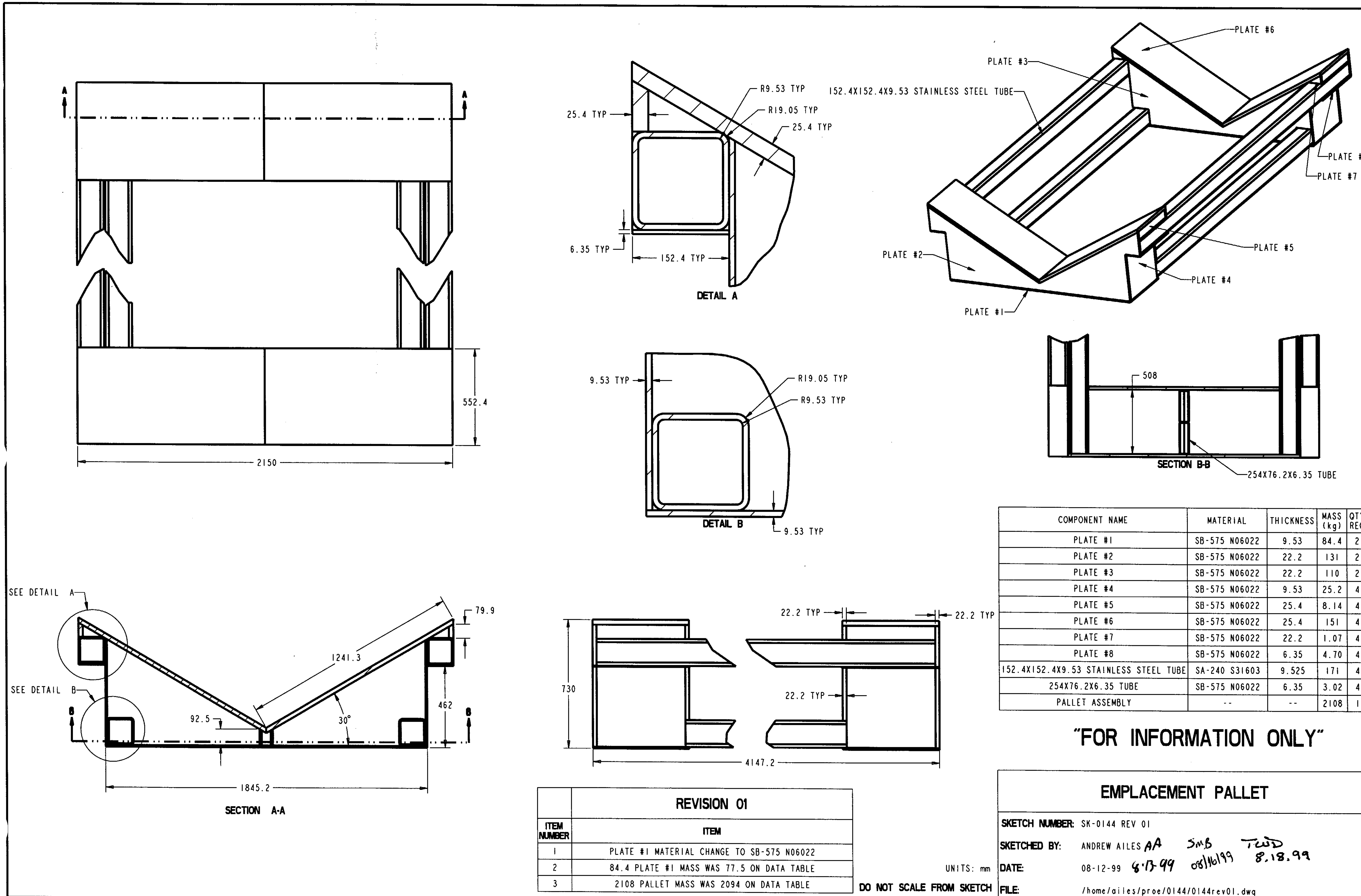


Figure II-2. Drift Cross Section Showing Emplaced Waste Package and Drip Shield



COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
PLATE #1	SB-575 N06022	9.53	84.4	2
PLATE #2	SB-575 N06022	22.2	131	2
PLATE #3	SB-575 N06022	22.2	110	2
PLATE #4	SB-575 N06022	9.53	25.2	4
PLATE #5	SB-575 N06022	25.4	8.14	4
PLATE #6	SB-575 N06022	25.4	151	4
PLATE #7	SB-575 N06022	22.2	1.07	4
PLATE #8	SB-575 N06022	6.35	4.70	4
152.4X152.4X9.53 STAINLESS STEEL TUBE	SA-240 S31603	9.525	171	4
254X76.2X6.35 TUBE	SB-575 N06022	6.35	3.02	4
PALLET ASSEMBLY	--	--	2108	1

REVISION 01

ITEM NUMBER	ITEM
1	PLATE #1 MATERIAL CHANGE TO SB-575 N06022
2	84.4 PLATE #1 MASS WAS 77.5 ON DATA TABLE
3	2108 PALLET MASS WAS 2094 ON DATA TABLE

EMPLACEMENT PALLET

SKETCH NUMBER: SK-0144 REV 01

SKETCHED BY: ANDREW AILES AA SMB TWD

DATE: 08-12-99 8-13-99 08/16/99 8.18.99

FILE: /home/ailes/proe/0144/0144rev01.dwg

Figure III-1. Emplacement Pallet

COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
PLATE #1	SB-575 N06022	9.53	84.4	2
PLATE #2	SB-575 N06022	22.2	131	2
PLATE #3	SB-575 N06022	22.2	110	2
PLATE #4	SB-575 N06022	9.53	25.2	4
PLATE #5	SB-575 N06022	25.4	8.14	4
PLATE #6	SB-575 N06022	25.4	151	4
PLATE #7	SB-575 N06022	22.2	1.07	4
PLATE #8	SB-575 N06022	6.35	4.70	4
152.4X152.4X9.53 STAINLESS STEEL TUBE	SA-240 S31603	9.53	102	4
254X76.2X6.35 TUBE	SB-575 N06022	6.35	3.02	4
PALLET ASSEMBLY	--	--	1834	1

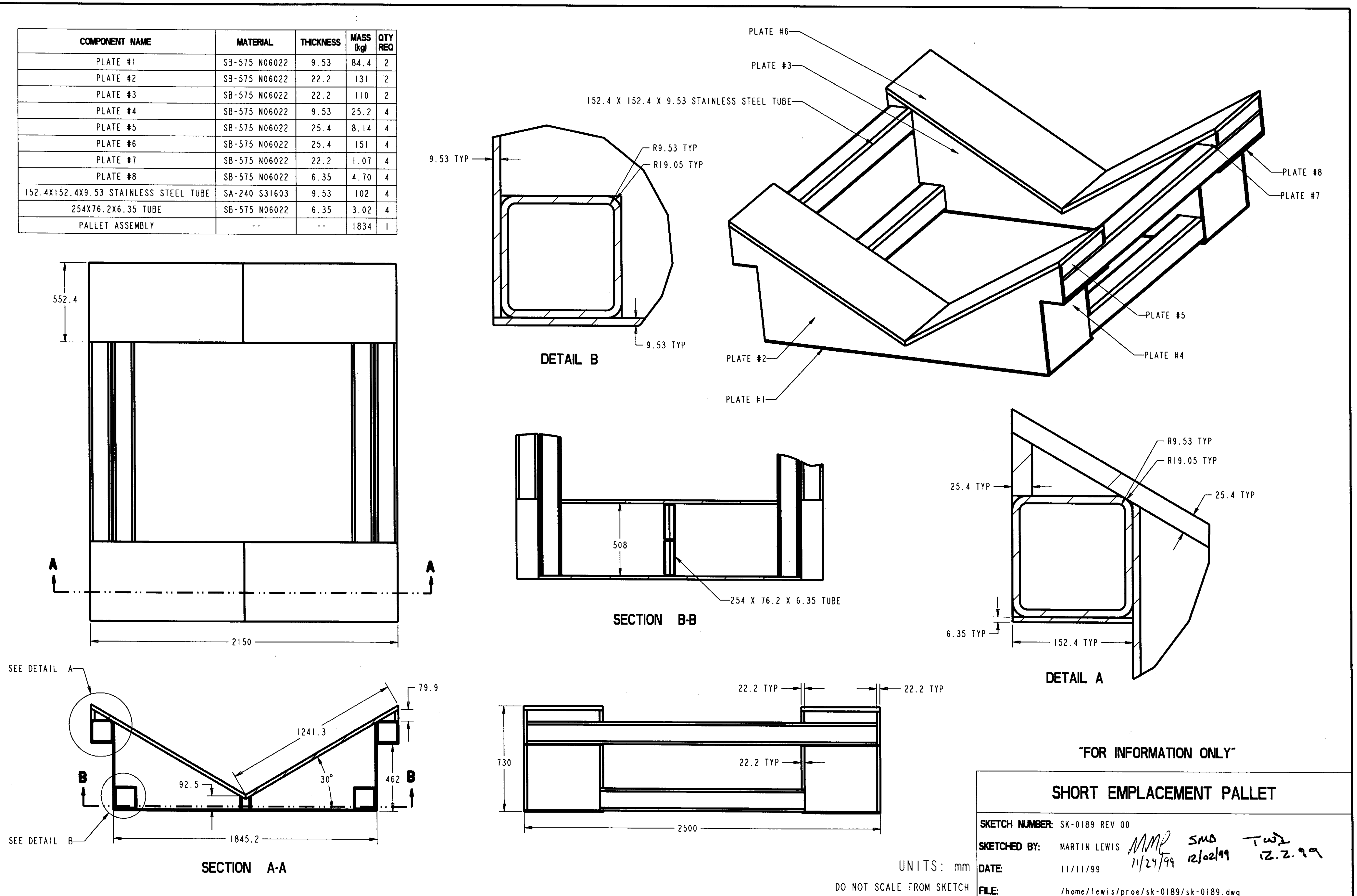


Figure III-2. Short Emplacement Pallet